THE JUNE SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

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The purpose of this book on psychiatry is to correlate the various currents of psychologic knowledge that have arisen in the past with present-day therapeutic work. The author is senior psychiatrist at Bellevue Hospital and assistant professor of psychiatry at New York University.

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RECENT BOOKS OF SCIENTIFIC INTEREST

The Development of Modern Medicine. R. H. SHRYOCK. xv + 442 pp. Illustrated. $4.00. University of Pennsylvania.

The relation of medical science to the social history of humanity and an interpretation of the social and scientific factors involved is the theme of this volume. The author traces the development from the 17th century until the present time.

In Quest of Gorillas. W. K. GREGORY and H. C. RAVEN. Illustrated. xvi + 241 pp. $3.50. Darwin.

A narrative of an American Museum of Natural History-Columbia University expedition into the heart of Africa in search of gorillas, relating scientific details, descriptions of nature, people and animals. It is the March selection of the Scientific Book Club.

Culture Methods for Invertebrate Animals. Edited by P. S. GALTSOFF, F. E. LUTZ, P. S. WELCH, J. G. NEEDHAM. xxxii + 590 pp. $4.00. Comstock.

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THE SCIENTIFIC MONTHLY

JUNE, 1937

CHEVREUL AS PSYCHOLOGIST

By Dr. JOSEPH JASTROW

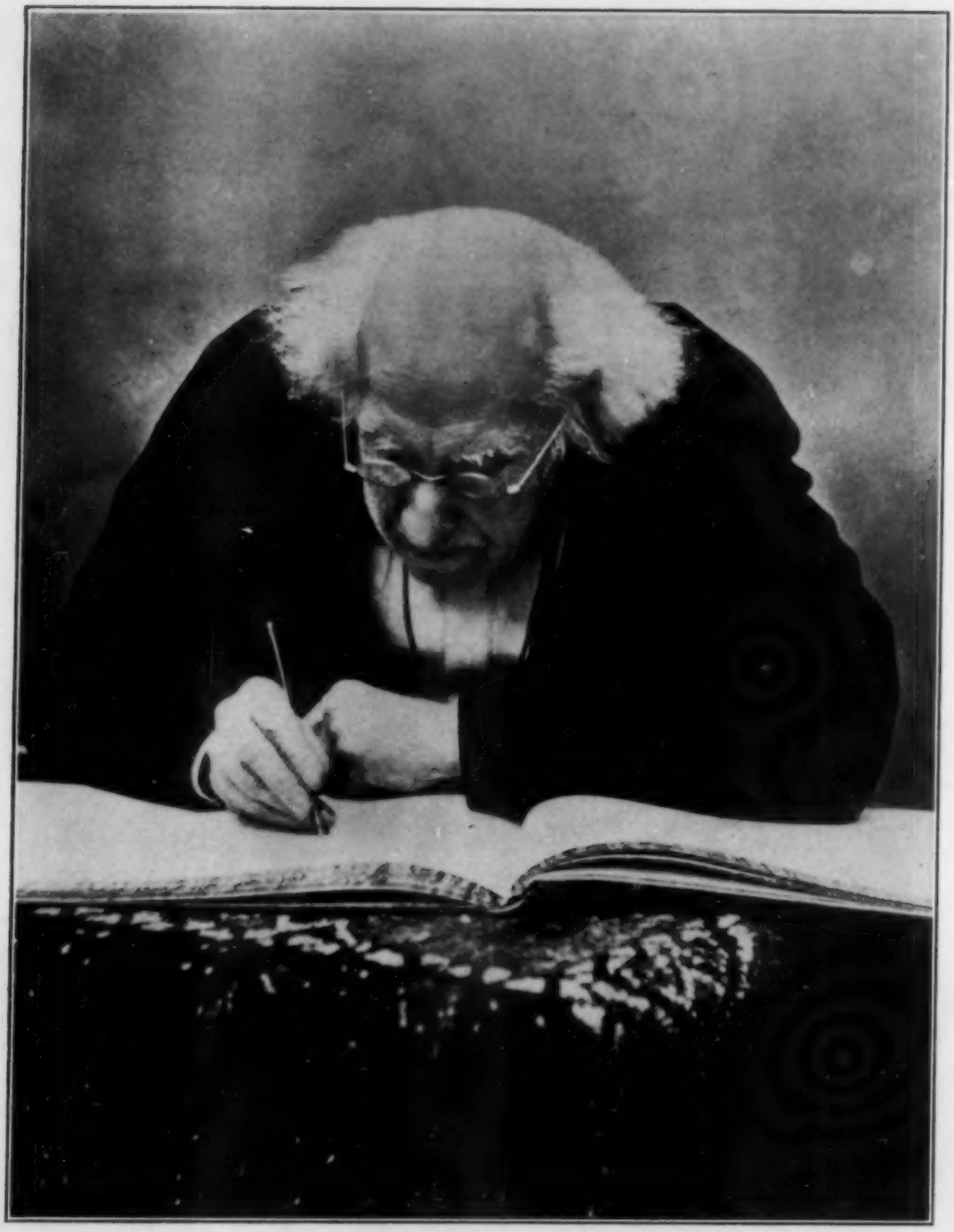
EMERITUS PROFESSOR OF PSYCHOLOGY, UNIVERSITY OF WISCONSIN

THERE are here reproduced by the courtesy of *Life* the remarkable "candid camera" photographs taken in Paris in 1886 by Paul Nadar. They represent a remarkable man, Michel-Eugène Chevreul, distinguished chemist, physicist and, what is less well known, psychologist, an all-round man of science of the nineteenth century. His claim to interest is enhanced by the fact that he lived to the remarkable age of 103 years. Among the photographs is one showing the centenarian seated at a table with his son, aged 70, and a friend, discussing the philosophy of life, indicating an amazing activity of mind in old age.

There are several confrères of Chevreul still living in Paris, who remember him in his later years. As he was a boy of thirteen when Washington died, his life-span links the ages. There are in his career two episodes, separated by several decades, which proved his mettle as a psychologist—not a professional one—but by virtue of temperament and training possessing an insight into the treacherous ways of mind under prepossession. Chevreul was a spokesman for "natural causes" as opposed to the recourse to occult, mysterious and supernatural explanations. In his own words: "I hope to show in precise manner how *des gens d'esprit* under the influence of the love of the marvelous so natural to man, break through the limitations of the known and finite and have recourse to the *cachet de merveilleux et du surnaturel.*"

Before relating the incidents that brought Chevreul into the domain of psychology, it may be well to recall his contributions to chemistry. Dr. C. A. Browne, supervisor of chemical research, in the U. S. Department of Agriculture, kindly contributes the following sketch:

Michel-Eugène Chevreul (1786–1889) was born at Angers, France. His professional education began at Paris in the chemical laboratory of Vauquelin, whose assistant he afterwards became at the Museum of Natural History. In 1813 he was appointed professor of chemistry at the Lycée Charlemagne. It was during his association with Vauquelin that he began his important researches culminating in the publication in 1823 of the work on "Animal Fats." He demonstrated that animal fats are compounds of glycerin with various fatty acids, a number of which he isolated and characterized for the first time. His work in this field led to great improvements in the manufacture of soap and candles. In 1824 Chevreul was appointed director of the Dye Works of the Gobelins Tapestries, where he conducted researches on the chemistry of dyes and on color contrasts. In 1826 Chevreul was elected a member of the French Academy of Sciences, becoming also in the same year a foreign member of the Royal Society in London. In 1830 he succeeded his old master Vauquelin as professor of chemistry at the Museum of Natural History, of which he was also director from 1860 until his retirement in 1879 at the age of 93. For his important work upon stearic candles, Chevreul was awarded a prize of 12,000 francs in 1852. In his investigation of the substances formed upon boiling meat, Chevreul discovered the new organic compound creatine; he contributed also to the chem-



MICHEL-EUGENE CHEVREUL

AT THE AGE OF ONE HUNDRED, SIGNING THE REGISTER IN PAUL NADAR'S STUDIO.

istry of vegetable coloring matters. He issued a volume of memoranda on the history of chemistry, including alchemy. No other chemist has witnessed in the course of his life so long and so great a development of his science.

Chevreul came from a distinguished family, which for generations had taken an active part in the scientific and social life of their day; his father was an eminent physician. Through his association with the Gobelins industry, which he served to revive, he investigated the physics and psychology of color. For a score of years he lectured to artisans on the use of color. He formulated the laws of color contrast, distinguishing between simultaneous and successive contrast. For he realized that the positive and negative after-images were responsible for the subjective effects. The change of color-value upon different backgrounds —again introducing complementary contrast—and the differences in the "laws" of pigment and of color mixture were applied to the color schemes of textile and other designs.

There are some details of the life of Chevreul collected by his granddaughter, Madame de Champ, in 1930. She has preserved the contemporary accounts and interviews of the great celebration of Chevreul's one hundredth birthday on August 30, 1886. It was a festive occasion for the entire city of Paris, with receptions at the Hôtel de Ville, the Academy of Sciences, the museums, special gala performances at the Opera and the Odeon and a torchlight procession through the streets. He was accorded many honorary degrees by great universities, including Harvard. At his death in 1889, he was given a public funeral.

Reporters were active in obtaining Chevreul's reminiscences: of his visit to the Crystal Palace at London in 1851 (only a few months ago destroyed by fire), where he was received with honors; of his life during the siege of Paris, 1870–1871, where he presided at meetings of the academy, though he was then 85 years old, and expressed his consternation that a war of invasion and defeat should obstruct the progress of science. He recalled his official examination for a medical degree of a young man who impressed him with his great promise and whose name was Louis Pasteur. But mostly the interviewers of the distinguished centenarian were interested in the personal habits responsible for his amazing activity and longevity. Questioned as to his use of stimulants, "No," he said, "I was never able to take even a glass of wine, without its upsetting my digestion." He recognized its benefits to others, as he added: "I was president of the Société de Vins d'Anjou—only the honorary president, however." Beer was equally distasteful to him; nor could he endure tobacco smoke, explaining that his son was an inveterate smoker, but careful to keep the odor of smoke away from his father. So he drew no morals, assumed no poses; he just rejoiced in his fortunate heredity and habits.

The distinction here to be accorded Chevreul in commemorating the one hundred-and-fiftieth anniversary of his birth is the recognition of his services as a psychologist; for his flair in that direction, though touching the discipline at only a few points, was keen. Because of his psychological interest, he has recorded a chapter in the history of science that otherwise would have been forgotten. It appears in a memorable volume entitled "De la Baguette Divinatoire, du Pendule, dit Explorateur et des Tables Tournantes," 1854. The occasion thereof was the vogue of table lifting and of spiritualistic seances of the fifties, imported from the United States, for in reversal of the movement of empire westward, the empire of cults moved (or returned) eastward. The immediate occasion was the appointment of a committee of inquiry by the Academy of Sciences to inform the public as to the scientific interpretation of table-turning.

"LES SENTIMENTS MORAUX DE L'HONNÊTE HOMME EXCEPTÉ, JE SUIS PRÊT À ABANDONNER TOUT CE QUE JE FAIS, SI ON ME DÉMONTRE PAR EXPÉRIENCE QUE JE ME SUIS TROMPÉ!"—EXCEPT FOR THE MORAL FEELINGS OF AN HONEST MAN, I AM READY TO GIVE UP EVERYTHING I AM DOING IF IT IS PROVED TO ME BY EXPERIENCE THAT I AM WRONG. CHEVREUL'S SON IS SEATED AT THE RIGHT; THE PHOTOGRAPHER'S FATHER, FÉLIX GASPARD NADAR, IS STANDING. THE LATTER APPEARS SEATED IN THE FOLLOWING PHOTOGRAPHS. THE SECRETARY WHO RECORDED THE CONVERSATIONS IS SHOWN STANDING IN THE LAST PICTURE.

Chevreul was made the chairman and wrote the report. He made of it an extensive historical inquiry into the ancient and modern employment of the principle which he called that of the "exploring pendulum," and which we speak of as that of *subconscious and involuntary movement*.

The interpretation of the dipping of the "divining rod" in locating water, (and later, oil), as an involuntary movement of the forked stick in the hands of the dowser, was current long before Chevreul. Since Chevreul, that interesting chapter in the story of involuntary movements has been fully recorded by Sir William Barret in the *Proceedings of the Society for Psychical Research*. But if we go back a century or more, we come upon a very different attitude toward the mysteries of the divining rod. We then find a philosopher, Malebranche, discussing with a Father LeBrun (1689) the origin of the force that directed the witch-hazel fork to underground fortunes. Père LeBrun argued that since it was not the work of either God or the angels, the force must emanate from the devil. The same device was used to detect crime; and a learned physician of the same day contributed the remarkable hypothesis that "the corpuscles exhaled in the transpiration of the body of a murderer differ in the pattern of their arrangement from what they would have been had he not perpetrated the crime." Malebranche argued for a more rational explanation. Chevreul thought it well to present the background of outgrown beliefs, to make clear the gradual triumph of science over the occult.

The phenomenon that gives the second title in Chevreul's memoir is both more ancient and more modern; for it goes back to Roman days and has been revived even in our own day. It reached its peak when Chevreul was a young man, and to the generations since has been a forgotten episode. In 1808 appeared a book with the title "Le Pendule Explorateur," by Professor Gerboin of Strasbourg, one of a group of physicists who recorded hundreds of experiments demonstrating a new force. They felt confident that they were inaugurating a new chapter in physics. It fell to Chevreul—though not to him alone—to make plain that they were contributing to learned error, through ignorance of what since then has become a familiar psychological principle.

The apparatus or "pendulum" employed was very simple—substantially nothing more than a weighted ball suspended at the end of a string. The observations noted that the pendulum swung one way for one kind of substance or influence, and in an opposite way for another. It was claimed that when the string, with a bit of iron, sulfur, gold or other metal suspended from it, was held over the north pole of a magnet, the movement was from left to right, and over the south pole from right to left; held over copper or silver, it went right to left; over zinc or water, left to right; if held in the left hand, the movement was reversed; if held over an apple with the stem upward, it moved one way, if over an apple with the blossom-end upward, in the opposite way; if held over the head of a human subject, it rotated "positively," if over his feet, "negatively."

Pursuing their theories, they held that the force responsible for the movement was either "expansive" or "compressive," actively or passively perturbed, according to the form of movement of the pendulum. They found oxygen to be expansive and hydrogen compressive; the tips of the fingers were expansive, the middle joints compressive; some minerals were found to be expansive, and the diamond was neutral. This entire alleged new chapter in science is wholly mythical, the result of expectant suggestion. *The ball swings as you think it will or should.* It swings so readily

"JE NE VOUS AI PAS TOUT DIT! MAIS DIRE N'EST RIEN, IL FAUT PROUVER, FAIRE VOIR. JE VOUS FERAI VOIR, IL FAUT QUE VOUS VOYEZ, PARCE QUE C'EST QUAND JE VOIS QUE JE CROIS."—I HAVEN'T TOLD YOU EVERYTHING. BUT TO TALK IS NOTHING. ONE MUST PROVE, MUST MAKE SENSE. I WILL MAKE YOU SEE. YOU MUST SEE BECAUSE WITH ME SEEING IS BELIEVING.

"JE N'AIME PAS M'OCCUPER DE PLUSIEURS CHOSES À LA FOIS!"—I DON'T LIKE TO BE BUSY WITH A LOT OF THINGS AT ONCE.

that the holder is wholly unaware that he is giving the impetus. The theory is all a rationalization upon a mistaken premise.

And that was Chevreul's principle of explanation. He proved it by experimenting upon himself; for at first he too found that the pendulum worked, as predicted, when held over a dish of mercury. He made his "exploring pendulum" by attaching an iron ring to a thread of flax. To test whether a physical force operated the pendulum, he interposed a glass plate between the iron ring and the mercury. Again, to his surprise, the oscillations diminished and then stopped entirely, and started again when the glass plate was removed. Suspecting that the movement was due to the difficulty in holding the pendulum steady with a free arm, he rested his arm on a support; the oscillations diminished but did not cease. Still suspicious, he had his eyes blindfolded and let some one else interpose the glass plate without his knowing when; and *nothing happened,* though he held the pendulum still for fifteen minutes. This observation marks an important moment in the annals of suggestion.

Chevreul had made a great discovery, which stood by him for life. "So long as I believed the movement possible, it took place; but after discovering the cause I could not reproduce it." He adds that the experiments "might be of some interest for psychology and even for the history of science." They show how easy it is "to mistake illusions for realities, whenever we are confronted by phenomena in which the human sense-organs are involved under conditions imperfectly analyzed."

When accordingly in 1853 Paris went wild over turning and talking tables, Chevreul had only to bring forward his notable letter to his friend Ampère, published in the *Revue des Deux Mondes* in 1833, concerning a "particular class of muscular movements," which established convincingly the principle of involuntary movement. But these experiments were actually performed in 1812, when Chevreul was twenty-six years old, and as a direct challenge to the Gerboin group of physicists. So the span of Chevreul's interest in this psychological problem covers the period from 1812 to 1854.

He thus brought together under one principle three phenomena which popular belief and practice presented to science; dowsing, a "vulgar error" supported by some "scientific" investigation; the "exploring pendulum," contributed by prepossessions of a group of physicists;[1] and table-moving, a spiritualistic phenomenon. The divining-rod is an ancient practice, retaining adherents to-day; there was held a congress of "diviners" in 1932. The ball and string, as a fortune-telling device, goes back to Roman days, when it was held inside a tall glass. As the letters of the alphabet were spoken, the ball would swing to the side of the glass and ring out the correct letter. There are also accounts of holding the "pendulum" above a written alphabet and thus spelling messages, anticipating the Ouija board, which had its great vogue in the closing decades of the nineteenth century, but its predecessor in the fifties in the Spiritualistic movement.

The ball and string device was forgotten and resurrected several times, its latest appearance in our own century as a "sex-detector." The claim went forth

[1] Somewhat earlier (1845) than the table-turning episode, appeared the claims of Baron Reichenbach, a distinguished chemist, to the discovery of another new force which he named "Od," which likewise was found to have positive and negative qualities and to behave differently for different metals, etc. Here the error resulted from trusting the reports of "sensitives," mostly hysterical subjects following through suggestion the leads of Reichenbach's prepossessions. There is no record of Chevreul's interest in the episode of "Od." The details of these "aberrant beliefs" will be found in my "Wish and Wisdom," 1935.

"Arago avait dans son rapport sur l'heliographie omis de mentionner le nom de Nièpce, le véritable inventeur."—In his story on heliography, Arago has omitted to mention the name of the true inventor, Nièpce.

that in the hands of a man or when held over anything masculine, the ball would swing to and fro; and when held by a woman or over a feminine article, it would swing in a circle. It all occurs in accord with the principle that Chevreul enunciated.

The public agitation aroused by turning and communicating tables was far more wide-spread than that of any similar movement; it touched upon the vital issue of survival and the personal emotions of contact with the departed. The wave of spiritualistic seances rose even higher in England than in France, and there brought forward another distinguished champion of rational belief in the person of Michael Faraday. So two great leaders accepted the social obligation of science to correct false views and allay agitation. Faraday came to the same conclusion as Chevreul, that the table moved through the involuntary movements of the "sitters" and expressed their knowledge and wishes. Faraday reduced the matter to a test by a simple device consisting of two small boards with glass rollers between them, which was sensitive enough to indicate the slight involuntary movements of the hands of the "table turners."

Faraday mentions that he called on Chevreul at his laboratory in 1812 and again in 1845, but their interests were diverse. Chevreul had before him Faraday's report in the London *Times* (June 30 to July 2, 1853). Both distinguished scientists regarded it as an interruption to their scientific labors to devote time to correcting popular opinion; but the occupation was far more congenial to Chevreul than to Faraday. In his book, Chevreul gives an account of the origin of Spiritualism in New York State, and comments on the fact that mediums or their controls are "not always moral or polite or in good taste in their language," and depart from truth in their predictions. Faraday was roundly denounced as a "materialist" by "spiritualists" generally, and by believers in "psychic" powers, including Mrs. Browning. As Robert Browning wrote the satirical "Sludge the Medium," the two poets seemed to have been of different minds.

Faraday was sorely troubled by the credulous condition of the public mind. The sharp contrast of the two temperaments appears in a letter by Faraday complaining of the necessity of "turning the table on the table-turners." He writes: "Consider my age (61) and my weariness, and the rapid way in which I am becoming more and more inert." Faraday died in 1867; his memory had failed him completely. That an instance of remarkably early senescence and one of its extraordinary absence should have occurred in two distinguished men brought together by a common interest, gives an added touch of interest to this episode in one of the by-paths of psychology. Thus did a great chemist and a great physicist serve the cause of science by recognizing a psychological principle.

All these matters are familiar to-day, but were far from generally recognized in those seemingly distant days when the generations contemporary with Chevreul —for he overlapped several—were demonstrating the practical benefits conferred by science and the principles of right thinking which they fostered. In the line of this rationalistic tradition Michel-Eugène Chevreul deserves a distinguished place.

COLLECTING FOSSIL ALGAE OF THE CANADIAN ROCKIES

By Dr. CARROLL LANE FENTON and MILDRED ADAMS FENTON
WEST LIBERTY, IOWA

LIKE all ranges of the Rocky Mountains, those in Banff and Yoho National Parks are young. Scarcely 70,000,000 years have passed since they appeared as low chains of hills above forests in which armored dinosaurs roamed. Many of their peaks took form within the last thousand centuries, receiving their final steepening touches less than 10,000 years ago. If these figures still seem great, recall that the present Appalachians have passed the 200,000,000 year mark and still are by no means the world's oldest mountains.

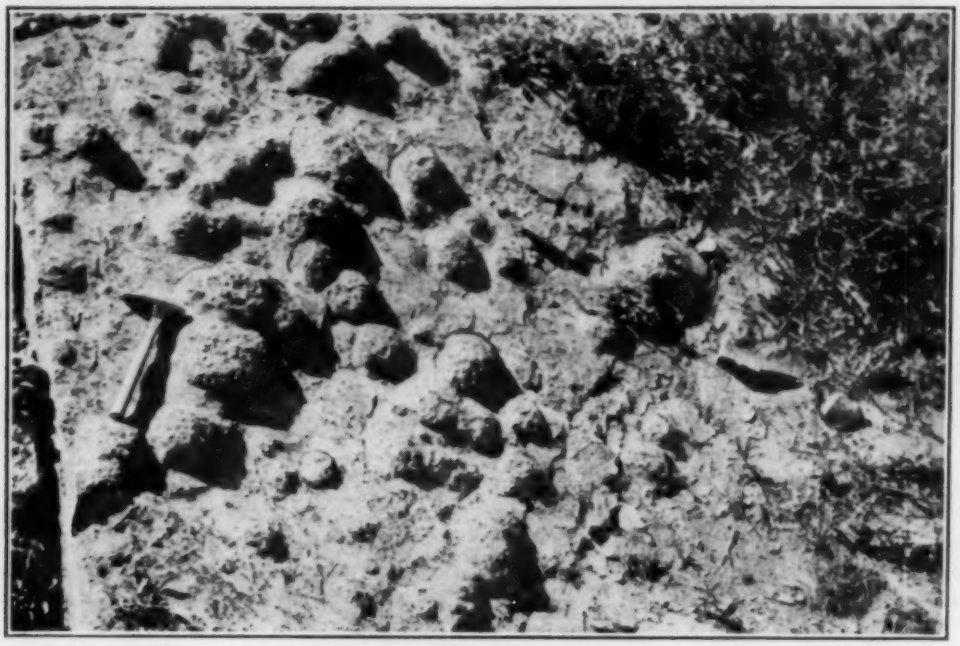
Despite their youth as highlands, the Canadian Rockies contain strata that are very old. Deposited in Proterozoic times, the age of the most ancient may be estimated at 650,000,000 years. Great thicknesses date from the early Paleozoic era, 400,000,000 to 540,000,000 years ago. Comparatively few were formed in the Mesozoic or "Age of Reptiles" and so are less than 200,000,000 years old. Most of these rise in rounded foothills or lie in valleys near Banff, forming no significant part of the mountains even along their front.

The older rocks were formed during times when what now is western Canada lay beneath shallow seas. Those seas stretched southward from the Arctic Ocean, linking waters with others that advanced across central North America or crept northward from bays in Arizona. Into those seas many rivers drained, bringing loads of sand, silt and dissolved minerals that sank and hardened into beds of stone. Through age after age those sediments settled, till they formed vast thicknesses of rock in the sinking marine basin.

Deposition was interrupted, of course. At some times little waste came from land; at others there was a great deal. During several epochs the sea floor arose till the hardened muds and sands were exposed, to be worn by winds, rains and streams. But time after time they sank again and were covered by new sediments. Not till the Mesozoic Era ended did uplift achieve dominance as tremendous forces, pushing from the westward, bent and raised the hardened rocks. Before that shove the strata formed folds, slid over one another or broke into great, tilted blocks. When the earthquakes of uplift ceased, those blocks formed ranges of mountains rising high above the plains.

Those mountains were what took us to Banff in search of primitive fossil plants. Rocks containing them lay beneath the plains; but where mountain building had not exposed them, they were deeply covered by later strata. In the Rockies, ancient marine beds stood forth in cliffs, ridges and the walls of canyons. What if they were tipped awry, bent or crossed by those breaks known in geology as faults? They were out where they might be seen and reached—and good roads or trails, built for tourists, led to many of them.

While other visitors danced, golfed or admired the Banff view, we were busy with topographic maps. We sought advice from alpinists and guides, examined specimens in the park museum, and discussed routes with a warden who amazed



ALGAE AS THEY GREW

THESE COLONIES BELONG TO A NEW GENUS AND SPECIES. THEY LIE UPON HARDENED SEA MUDS WHICH A GLACIER PLUCKED FROM A PEAK AND DROPPED IN THE WIDE CORAL VALLEY.

us by knowing what fossil algae were. He also urged us to keep watch for living things. "There will be mountain sheep in that canyon and goats on most of those ridges. On the Pass, keep an eye out for grizzlies; they will do no harm but are worth seeing, and it's great to watch one dig for squirrels. If you camp, watch out for wolverenes: some of 'em live near Fossil Mountain. There's naught can wreck a grub cache so bad as a hungry wolverene!"

Our first finds were made near the highway, barely six miles from Banff. Passing beaver ponds with their unkempt houses, we came to a salt lick prepared so that bus passengers might see mountain sheep. Four rams mounted a slope as we approached and watched while we struck out through the woods. The indistinct trail merged with a creek bed which became a channel filled with rocks dropped by a vanished glacier. Several showed deep scratches made when the ice forced them against other sharp stones.

Where the channel became a box canyon we found beds filled with fossil plants. Each fossil was a biscuit-shaped mass of limestone one to four feet in height, probably built by several species of jellylike red algae living in close association. As they grew these algae deposited layers of the mineral calcite within their jelly. When growth was rapid the layers were thick; when it was slow, they were thin; when it almost stopped, breaks or partings were left between layers. Very probably, a layer and a break represent a year, for plant growth in ancient northern seas must have been helped by the long days of summer and retarded by winter, when days were short and the sun stood low. We looked for

THE "GIANT'S PAVEMENT"

BEDS OF THE LARGE ALGAE CALLED *Collenia (?) prolifica* BY WALCOTT. THEY LIE BARELY THREE MILES FROM THE FAMOUS SKOKI CLIMBING AND SKI CAMP.

definite seasonal layers in limestones containing the fossils, but failed to find them. The most we could discover was rocks in which complex carbon-stained bands seem to indicate periods of several years in which plant life was abundant, separated by intervals in which it was scarce.

The Banff fossils looked much like some discovered years before by the late Dr. Charles D. Walcott, who spent many summers collecting in the Rockies. We might have gone direct to Walcott's locality by trail, past mountains amazingly tilted, bent and broken by uplift. It was simpler, however, to start from Lake Louise. Even there, it seemed that we should need a guide, pack string and camp outfit—all the troublesome essentials of collecting among mountains far from lodges or camps.

A chat with a warden showed us to be wrong. "Need a pack outfit to reach Tilted Mountain? No! Didn't any one in Banff tell you that Jim Boyce keeps his ski camp open all summer? Go up when and as you please, with no worry about packs. Stay in one of Jim's cabins: the beds are good and so is the grub. Collect as many days as you like, use horses if you wish, and let Jim pack your fossils out. He'll leave 'em for you here at my cabin. And if I can do anything for you, just send word down by a guide."

Thus we found ourselves "camped" in a log lodge where dinner was served in courses and strawberries (packed thirteen miles on a cayuse) greeted us at breakfast. We also were able to answer critics who maintain that geology blinds one to other phases of nature and mars every fine scene. For four days we climbed and collected among alpine ranges where gray, buff and brick-red rocks were tilted into beautiful patterns.

THE RECORD OF ANCIENT FLOOD OR STORM

PEBBLES AND MUD WERE MIXED TOGETHER IN THIS BRECCIA, PERHAPS 650,000,000 YEARS OLD.

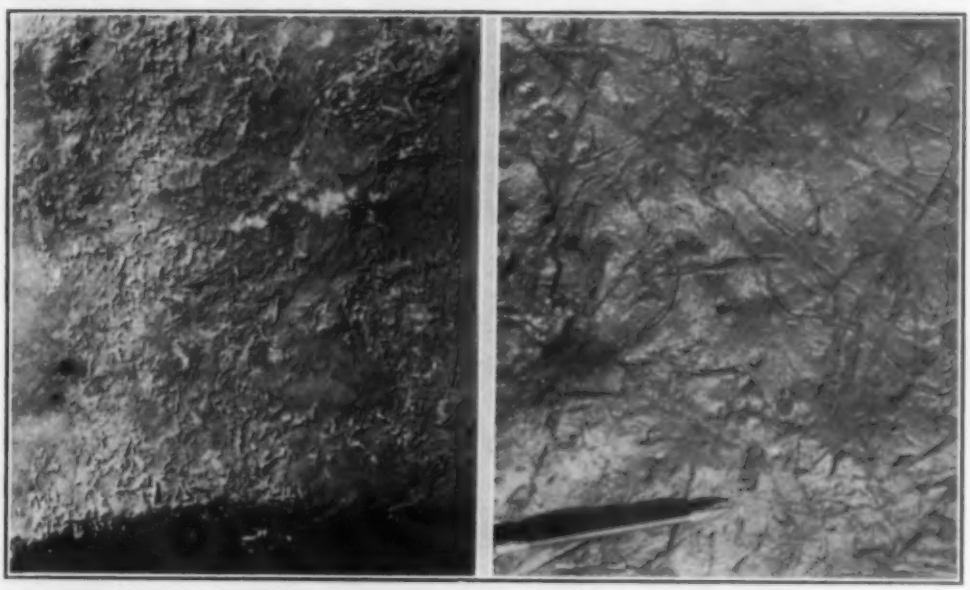
SADDLING AND PACKING

A GUIDE HAS COME FOR THE COLLECTORS AT THE END OF A DAY'S WORK NEAR PTARMIGAN AND PIKA PEAKS, A DOZEN MILES FROM LAKE LOUISE.

They lost none of their design because they appeared as limestones, dolomites and quartzites thrown into blocks by faulting. Peaks were not ships or castles, it is true, but they gained meaning as the results of structure, weathering and erosion. A folded and faulted ridge lost whatever poetry it may have possessed as the "giant's washboard," but it received its due of glamor from a tale of hardening, compression, uplift and fracture running through 300,000,000 years.

"giant's pavement" that proved to be dolomite filled with masses of algae.

Those algae, discovered and named by Walcott, did not grow in domes or reefs. Instead, they covered the sea floor in banks, their colonies crowded so closely that they grew in odd, distorted columns. Little mud was able to settle between them, but there was even less in the water covering the massive plants. Many of the colonies surround cavities that still are but partly filled with sediment, though they must have remained open



TRACES OF ANCIENT LIFE

Left: "NULLIPORE" ALGAE—PART OF A SLAB IN WHICH SMALL, BRANCHING FOSSILS LIE IN A MATRIX OF HARDENED LIME MUD. *Right:* FOSSIL SNAIL TRAILS—TRAILS MADE BY SNAILS THAT CRAWLED AND FED ON CAMBRIAN SANDS 540,000,000 YEARS AGO.

"Other phases of nature" would not be ignored. Structure of fault blocks explained groves of larches, varied strata accounted for waterfalls, and the melting of a small glacier provided hoary marmots with homes. Ptarmigan chuckled while we examined a conglomerate and a mountain goat stopped to watch as we measured beds of micaceous shale. A mule deer met us on the

for years before algal growth covered them.

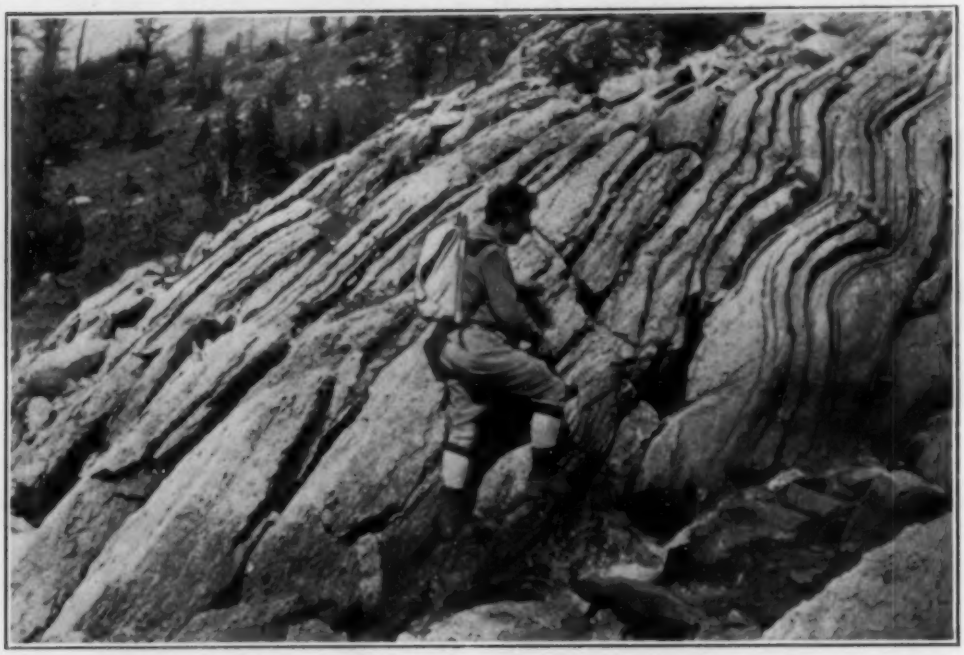
Though clear and free from coarse mud, water on the algal banks was shallow. Where plants did not protect the bottom, small waves were able to reach it and pile up ripple marks. In other places currents dug channels only a few inches wide. In many spots and times, storms broke up the half-hardened sea

floor and turned it into mud and pebbles. For a while these were tossed and rolled about; then the waters quieted and they sank to form beds of mud and flat pebbles. Some of these fill spaces between algae, while a few, in very ancient rocks, contain rolled bits and pebbles of algae broken and worn by storms.

Such rocks, called edgewise breccias or conglomerates, are common among floors bare as steaming sand or mud flats.

The Canadian sea was not so shallow, but it plainly was not very deep. Many strata gave evidence of shoals, while others formed in later seas showed kindred structures. Not one bed suggested deposition in water of great depth.

Like many shallow-sea deposits, these were rich in fossils. In one limestone we came upon true reefs, though they did



FOLDS OR FOSSILS?

LAYERS SO COARSE AND SO THOROUGHLY CRYSTALLIZED THAT THEIR NATURE CAN NOT BE DEFINITELY DETERMINED.

formations containing algae, as well as in many others. With or near them are mud cracks, ripple marks, current channels, rain prints and other traces that mark shoals or mud flats. Even when doubtful cases are omitted, they seem to prove that many ancient seas were shallower than the majority of modern lakes. Over hundreds, even thousands, of square miles they were less than thirty feet deep. Some contained so little water that each dry season laid their

not reach three feet in thickness. A slope provided many corals, broken by glaciers from strata exposed on the high slopes of Fossil Mountain. Blocks of gray limestone near a pass were filled by round balls called pisolites. They gave promise, at least, of being algal; so we took all the specimens we could carry in comfort. Why shouldn't we when the cabin and our *cache* were barely a mile away?

We planned to walk that mile in haste;

UPLIFTED MARINE BEDS

THESE CLIFFS OF LIMESTONE AND DOLOMITE BEGAN EXISTENCE AS LAYERS OF MUD IN A SEA THAT STRETCHED SOUTHWARD FROM THE ARCTIC OCEAN.

A BANK OF LARGE ALGAE

HERE HUGE COLONIES OF LIMY RED ALGAE GREW SO CLOSELY TOGETHER THAT THEY FORMED BEDS OF ROCK, EVEN WHILE THEY STILL WERE ALIVE.

instead, we stopped long beside a slab lying near a small creek. It had been plucked, carried and dropped by a glacier melting as it moved toward the Bow Valley. Throughout these adventures, it preserved two dozen biscuit-shaped masses of algae belonging to a new genus and species. They dotted the upper surface of the rock, lying as they once grew on the muds of a Cambrian sea floor. Again camera, notebook and tape were used; then a chisel pried off specimens that filled both knapsack and arms. That last mile to the cabin was not made quickly, and many sighs of relief were heard as those algae joined the lot waiting for pack-horse and packer.

After Lake Louise came Yoho Park, whose fossils have made it famous even where its scenery is unknown. Dr. Walcott found excellent animal remains at Ross Lake, but made no mention of algae. We were lucky enough to find three types: one the shape and size of pigeon eggs, another so massive it almost made reefs, and a third that consisted of countless branches tangled into dolomite slabs. They suggested the modern "nullipore" algae, whose remains become indistinct a short time after they die. Other "nullipores" form rocks in the Big Horn and Teton ranges of Wyoming, where they look like mere coarse-grained versions of the strata in cliffs above Ross Lake.

Mountains a few miles away provided other egg-shaped algae, buried in sediment that was a mixture of dolomite and sharp-edged sand grains. The dolomite was precipitated from clear water; the sand may have been blown out to sea from arid lands bordering the Cambrian shoals.

A PAUSE ON A PASS

THE FOSSIL HUNTER IN CANADA'S ROCKIES FINDS HIMSELF IN PLACES OF SCENIC BEAUTY AND BIOLOGIC INTEREST. HERE IS HIGH ALPINE COUNTRY—AT AN ELEVATION OF BARELY 8,200 FEET.

WALCOTT'S BURGESS SHALE QUARRY

AUTHORS ARE COLLECTING FOSSILS OF PLUME-LIKE ALGAE FROM SLABS DISCARDED BY EARLIER WORKERS.

Sandstones of greater age contained no algae, but they did bear the filled trails and burrows of bottom-dwelling animals. Some trails were made by snails as they crawled and fed on the soft bottom. We could trace ridges pushed up and pressed by shells, furrows dug by wide, soft feet, and cross wrinkles built as the muscles in those feet contracted. Mud and mica grains in the sands made them so plastic that the trails were preserved long after the snails vanished.

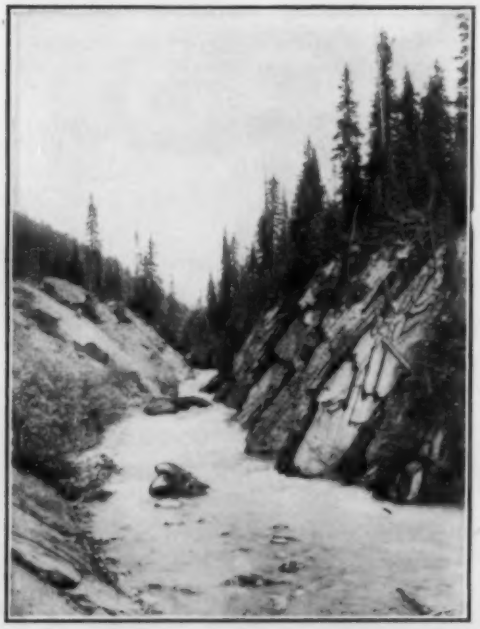
Many burrows probably were the work of annelids, but a few, marked by criss-cross lines, plainly were the work of trilobites—ancient and remote cousins of the king crab. Whether they dug for food or to lay eggs is not certain; perhaps shallow burrows are food holes and deep ones are nests sunk into specially plastic sand. Trilobite "tests," like the shells of snails, were lacking. Both were dissolved by carbon dioxide in the dark, muddy sand.

Our next objective was the Burgess Shale quarry, where, in strata a half billion years old, amazing fossils have been found. The shale was discovered by Dr. Walcott in 1909 when he stopped to push a stone from the trail. Striking it with his pick (nicknamed Jonah), he split off a few black slabs. On them were remains of infant trilobites and round lamp-shells or brachiopods, preserved in shining films of carbon. Search located the ledge whence the loose block had come, on a ridge between Mounts Field and Wapta. Camp was pitched among firs far below, a quarry was opened, and thousands of fossils were taken out. For many summers Dr. Walcott and his aides returned, their collections now being among the chief treasures of the U. S. National Museum.

With binoculars we saw the quarry

from the chalet beside Emerald Lake. The trail to it was very steep, so we chose a longer but easier one climbing from the Yoho Valley. On the way, we paused to pick whortleberries, to watch a moose and to photograph ptarmigan chicks. Rocks lay near the trail on Yoho Pass, their bluish strata formed by branching coralline algae buried in dolomite. Specimens were selected and cached near a fir tree, to be picked up on the return trail.

At the quarry we set to work on slabs thrown aside by Walcott's collectors. The frosts of a dozen years had split them, revealing shells, trilobites and even glass sponges. More interesting to us were silky, carbonized filaments of green seaweeds that covered some surfaces. With them were fronds that seemed to be relatives of the laminarian seaweeds now found on many shores. Though there was no hint of shore lines on Mounts Field or Wapta, the strata did agree with others in giving evidence of shallows not far from the one-time Burgess Pool.



UPTURNED STRATA

ROCKS ALONG THE KICKING HORSE RIVER SHOW HOW INTENSELY ANCIENT SEA BOTTOMS WERE BROKEN AND TILTED WHILE THE ROCKY MOUNTAINS WERE RISING.

A trail through the Yoho Valley itself led to still other ledges of the supposed coralline algae. Then it passed two lakes, crossed a glacial creek, and in steep switchbacks climbed a ridge descriptively called the Whaleback. On its shoulder we paused to admire a maze of deep valleys, horn peaks and glaciers clinging to the faces of cliffs. Then we turned to algae as big as those in the canyon near Banff and from them to biscuit-shaped forms that would make still another new species. They may have lived in deeper water than the others, for beds among them showed ripple marks so large that we could pick them out on mountain sides more than a half mile away.

Work in the Yoho showed what an array of data are needed if fossils are to reconstruct life during remote ages. Good specimens are far from enough; they must be accompanied by descriptions and measurements of beds, rock samples for sectioning, plus photographs and annotated sketches dealing with sedimentary structures. A single fossil often required a half-dozen rock samples, three or four negatives and as many pages of notes. With so much to do, progress was slow. We called two miles per hour excellent speed on all but thickly wooded routes where few rocks could be found.

Our trips also showed how readily geology may be enjoyed by travelers equipped and willing to see it. Our companions on one day were physicists: they discovered some excellent fossils and wrestled with problems involving concretions. A school girl was with us at Yoho Glacier, where she learned what crevices and seracs meant. Two bell-

YOHO GLACIER

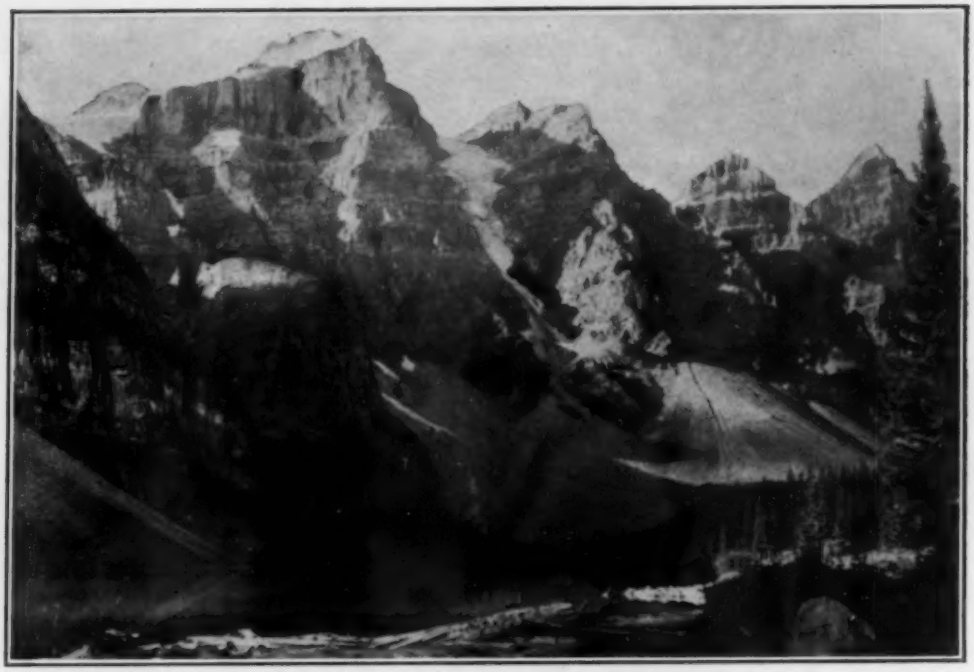
ONE OF THE MANY GLACIERS THAT STILL CARRY BLOCKS OF FOSSIL-BEARING LIMESTONE TO PLACES WHERE COLLECTORS CAN REACH THEM.

hops on leave visited strata so complexly folded and broken by faults that their proper sequence still is uncertain, and an attorney gained new respect for moraines while we looked for slabs of coralline algae small enough to go into knapsacks. He also marveled at our willingness to put stones in those packs, though miles of trail stretched before us. When geology meant such loads as those, how could we come to the mountains for pleasure?

Mid-August found us in the Valley of Ten Peaks, a few miles south of Lake Louise. In the party were our two physicist friends. Having walked through much of Yoho and Banff parks, they were ready to see more of fossils.

We took the trail one chill morning as clouds whirled about Wenkchemna Peak. For a thousand feet we climbed by switchbacks; then the trail entered a wide valley where larches already were turning yellow. It led to the bowl where a glacier once rose—a basin the geologist terms a cirque, but that prospectors know as a "half-kettle" valley. At the bottom lay a blue tarn whose bed had been dug in hard sandstone as ice ground and shoved its way down the valley.

Fossils were present, though not common. Sandstone ledges held tubes probably built by the worm-like creatures called phoronids. Other ledges contained trilobite tracks, but no pits showing where they had dug for food. At Sentinel Pass we found blocks of the egg-shaped algae, though slopes were too steep to permit climbing to the brown strata from which they came. We contented ourselves with a few talus specimens and then used binoculars to distinguish the larger rock groups making up the precipitous mountains.



FOUR OF THE GLACIER-CARVED TEN PEAKS

THEY ALMOST SURROUND A VALLEY NEAR LAKE LOUISE. BEDS OF EGG-SHAPED ALGAE LIE IN THEIR HIGH CRAGS, BUT SPECIMENS MUST BE SOUGHT IN DRIFT AND TALUS.

By a camp fire that night we discussed our finds. Our friends had specimens that defied purely physical explanation, though it had been suggested for fossil algae far more plantlike than those. They also possessed negatives that recorded rare views of glaciers, peaks and red-walled canyons descending to milky glacial streams. For us there were sections, notes on rocks too large for collecting and small slabs showing that egg-shaped algae grew widely in one Cambrian sea. For all, there were memories that would last, glimpses of beauty to be considered and problems that would call for solution long after we should leave the mountains and return to our lowland, workaday homes.

THE ANNUAL EXHIBITION REPRESENTING RESEARCH ACTIVITIES OF CARNEGIE INSTITUTION

By THE EXHIBITION COMMITTEE
CARNEGIE INSTITUTION OF WASHINGTON

ACTIVE interest in the current progress and development of scientific knowledge and a clear desire to appreciate the significance of these advances, especially in respect to what may be termed their human aspects, has been increasingly demonstrated by the intelligent public during the past fifteen years. Scientific investigators and teachers who are the readers of the SCIENTIFIC MONTHLY are being called upon with increasing frequency for expositions of their subjects which are suited to this general audience, and a description of the procedure which has been developed by the Carnegie Institution of Washington for the annual presentation to a non-technical audience of some of the latest developments in the program of the Institution may be useful to others in meeting a similar problem.

The Carnegie Institution, as is well known, is a research organization endowed by Andrew Carnegie, and its activities cover a wide field, with laboratories in various parts of the United States, with field investigations in every part of the world and with members of university staffs here and abroad as research associates. The Institution has three major departments in the physical sciences—Mt. Wilson Observatory, and the Geophysical Laboratory and the Department of Terrestrial Magnetism in Washington. The Division of Animal Biology includes the Department of Embryology in Baltimore, the Nutrition Laboratory in Boston and the Department of Genetics at Cold Spring Harbor, Long Island. The Division of Plant Biology has field stations and laboratories in many locations in the West. The Division of Historical Research spends a major part of its efforts in archeological studies of the Early American (Indian) culture.

This wide geographical distribution of activities is a factor of importance in assembling an exhibition of current research results. The trustees of the Institution hold their annual meeting at the Institution's Administration Building in Washington in December, and for many years it has been the custom of the president to arrange at that time a series of exhibits showing a selected group of recent developments in the Institution's researches. For three days after the trustees' meeting these exhibits are open to the general public. One of the primary factors which lends importance to these exhibits is the fact that the investigators who actually carried out the researches which are exhibited are also there in person to demonstrate or explain them and to give an opportunity to visitors for a close personal association with the work which can be achieved in no other way. The occasion of these exhibits has served as an opportunity to bring together each year some of the members of the research staff, and thus it has been possible to minimize the disadvantages inherent to the scattered geographical location of the departments.

The exhibits are organized by a committee which is appointed from year to year. This committee functions mainly as a coordinating agent. It helps in the

selection of problems to be exhibited; it handles routine arrangements in regard to the physical facilities; and it is responsible for supervision of the concise statements prepared by the investigators for the descriptive pamphlet which is issued every year. Exhibits are prepared by the members of the research staff whose problems are shown. The exhibits material is brought to Washington from the various laboratories and is assembled there.

On the last day of the exhibition the committee and the exhibitors hold a meeting at which, among other matters, suggestions as to the improvement of the exhibits are discussed. At these meetings the question is frequently raised as to whether the exhibits should be arranged and labeled so as to be self-explanatory or whether they should require a demonstrator. No general decision or agreement on this question has been reached. Since these exhibits represent individual research projects and are prepared by men who did the work and who in many instances are leaders in their respective fields, a certain degree of freedom in the choice of method of presentation is found to produce the best results. Each exhibit expresses the individuality of its author not only in respect to the problem but in respect to the presentation as well. This intimate relation between the exhibit and the men who did the research is the most valuable and unique feature of the Carnegie Institution exhibits. Not only are these exhibits prepared by the various investigators themselves, but, as mentioned above, these men are always on hand either to demonstrate their exhibits or to answer the questions of the visitors.

A series of seven or eight lectures, each twenty minutes in length, is arranged for the lecture hall during the three days. This gives each exhibitor an opportunity for a more connected and detailed presentation of his work to an audience which expresses its interest in his particular subject by attending at the time indicated. These concise and authoritative statements are very carefully prepared and later published, bringing to a wider public in a permanent form the essence of the temporary presentation of the work which the exhibit constitutes.

A short description will be given here of the eleven exhibits shown last December. This description follows closely the statements prepared by the exhibitors and published in a 56-page pamphlet distributed among the visitors.

The Present-Day Maya Indians of Yucatan

A broad historical project relating to the development of the Maya civilization comprises an important part of the Institution's program. Archeological investigations in Yucatan and Guatemala are supplemented by documentary, environmental, biological and sociological studies relating to the evolution of the Maya culture. This project constitutes the major part of the activity of the Division of Historical Research and is carried on in cooperation with several other departments of the Institution, as well as with a number of research associates located at several universities.

The exhibit on "The present-day Maya Indians of Yucatan," which was prepared by Dr. Morris Steggerda, of the Department of Genetics, showed the results of a study in which the Department of Genetics, the Division of Historical Research and the Nutrition Laboratory took part. It has been found that the Maya possess a uniquely high metabolic rate combined with a low pulse rate. This unusual condition may be innate, in which case it becomes a useful criterion of race; or it may be caused by environmental factors such as climate, clothing and food. A detailed study of the principal foods of the population in the village of Piste, Yucatan, reveals that corn (maize) forms 75 to 85 per cent. of the

FIG. 1. THE FOOD OF THE YUCATAN MAYA

SAMPLES AND MODELS OF VARIOUS FOODS, SAMPLES AND DESCRIPTIONS OF ACTUAL MEALS AND PHOTOGRAPHS ILLUSTRATING THE DAILY LIFE OF THE MAYA INDIANS OF TO-DAY.

diet of the Maya; meat forms 10 to 15 per cent. and vegetables 5 to 10 per cent. This high carbohydrate diet could not produce the conditions necessary to raise the basal metabolism; hence the solution of this problem must be sought elsewhere, either in the environment or in heredity. In winter the temperature in Yucatan often ranges from 50° to 100° Fahrenheit. In spite of this extreme variation the Maya live in houses loosely constructed of poles and thatch, wear very meager cotton clothing and sleep in hammocks with no blankets. How this condition affects the metabolism is still to be determined.

The exhibit consisted of three panels: one showing the results of metabolism measurements; one very large one showing samples and models of various foods, samples and descriptions of actual meals and photographs illustrating the daily life of the Maya (Fig. 1); and the third panel gave a family chart and a few items on vital statistics. Lantern slides in a Balopticon illustrated farming practices and daily life of the people.

ARCHEOLOGY OF THE GUATEMALAN HIGHLANDS

The geographical location of the Highlands of Guatemala is such that they probably have served as a contact place for the various aboriginal groups of Middle America. This locality, therefore, is of great importance for a historical study of the relations between the Maya and other Indian groups, a problem in which the Carnegie Institution of Washington is deeply interested. The results of last winter's excavation work in that locality were shown by the Department of Historical Research.

In the immediate vicinity of Guatemala City there is an assemblage of over a hundred large mounds named Kaminaljuyu or "Hills of the Dead," marking the ceremonial center of what must have been a very populous community. One of these mounds was cut last winter to make way for a football field. Part of a wall was thus laid bare, and this gave the first hint that important discoveries might be made by excavations in that region. Subsequent work revealed that

the mound is the remains of a rubble pyramid, the substructure of a temple which has entirely disappeared. Further digging disclosed within it, excellently preserved, the stuccoed walls of a smaller, older pyramid, which in turn covered a still smaller one. At the end of the season the side of the fourth pyramid was encountered. A series of tombs lying below and to the east of the superimposed pyramids suggests that funerary customs may have been involved in the erection of the successive increments of the complex.

The graves are vertical shafts, twelve to sixteen feet square by fourteen to sixteen feet deep. In each was found a skeleton of a male whose body, loaded with ornaments of jade, shell, iron pyrites and mica, had been placed, sitting cross-legged, in the middle of the floor. About the principal skeleton were piled offerings of pottery; and in the corners along the sides of the vault lay other skeletons without ornaments, doubtless slaves sacrificed at the time of interment. Three tombs were cleared. Each shaft could be correlated with one of the three outer pyramids. It appears, therefore, that on the death of a person of importance, presumably a high-priest or a ruler, the temple of the cult with which he had been associated was dismantled and a new and larger shrine was built.

Some of the vases and effigies are allied to pieces recovered by the Institution from Maya tombs at Uaxactun, Guatemala; while others bear strong resemblance to pottery from the ruined city of Teotihuacan in central Mexico.

The exhibit consisted of photographs of the site in the Kaminal-juyu region, of full-sized paintings of pottery in original colors and of models of pottery.

Pinocytosis—the Drinking of Fluids by Cells

This new term, signifying the drinking by cells of globules of the fluid which bathes them, corresponds to the term phagocytosis, eating by cells of solid and semi-solid particles. This new process was discovered by Dr. Warren H. Lewis, of the Department of Embryology, Baltimore, while he was studying the motion pictures of macrophages, the highly mobile blood cells which live in the tissues. Pinocytosis became apparent when the motion pictures were viewed at the customary speed, about 50 times the rate at which they were taken.

Pinocytosis is carried on by ruffle pseudopodia which project here and there from the cell and undergo a continual wavy motion. The ruffles are exceedingly thin sheets of protoplasm thrust out from various regions of the cell. They are not permanent organs but appear and disappear constantly. As the ruffles wave about in the fluid medium which bathes them, they may entrap a little of the surrounding fluid and, by complete fusion of a portion of the ruffle about the fluid, convert it into an enclosed globule which is thus brought inside the cell. When the enclosed globule reaches the central part of the cell, it is rapidly digested.

The drinking by the macrophages cultivated outside sometimes continues steadily hour after hour over a period of several days, and they may drink many times their volume of fluid in the course of a day. Sometimes pinocytosis is intermittent and frequently no drinking appears to take place.

Pinocytosis has been observed only in cells cultivated outside the body and only on two types of normal cells: macrophages and, rarely, the fibroblast. Certain types of malignant sarcoma cells, however, show lively ruffle pseudopodia and active pinocytosis.

At this exhibit a motion picture was run at frequent intervals, accompanied by a short lecture. Under the microscope were shown living macrophages and cancer cells undergoing pinocytosis, and this

same process was shown on enlarged photo-transparencies.

The March of Forests in Response to Changing Climate

An exhibit dealing with this topic was prepared by Dr. Ralph W. Chaney, research associate of the Carnegie Institution and chairman of the Department of Paleontology of the University of California. Fossils from the United States, Northern Canada, Alaska, Siberia, China and Greenland show that during the Eocene period identical forest vegetation covered that whole section of the earth. During that period in regions now too cold to permit the growth of such trees, there lived redwood, beech, elm, ginkgo, magnolia and oak trees, all of whose modern descendants now live in lower latitudes where the climate is relatively mild. Not only did temperate forests of redwood and oak extend far north of the present tree line, but trees now characteristic of the tropics have been recorded from Eocene rocks of middle latitudes in the United States. The fig, avocado, bread-fruit and tree fern suggest a past climate in Tennessee and Oregon like that now found in Mexico and Central America. Heavy rainfall and an absence of frost must have contributed to the existence of such subtropical and tropical plants in these now temperate regions.

In the western United States, forests of the Miocene age were so much like those in higher latitudes during the preceding Eocene period as to indicate that most of their elements came down from the north. In the course of this journey they appear to have changed in many minor respects, but they still retained the redwood as a conspicuous member, together with other broad-leafed trees which were present in the older forests of Alaska. Though not definitely known, it is probable that east of the Rockies and north of Virginia there may have been a redwood forest similar to that of the Miocene period in Oregon.

The changing climate, resulting in plant migration southward from high to middle latitudes, may have been due in large part to the gradual rebuilding of North America and the rise of mountain ranges along the Pacific. The Cascades appear not to have been sufficiently high in early Miocene times to shut off rain-bearing winds from eastern Oregon. Since the Miocene period, further mountain uplift has made eastern Oregon a semi-arid plateau in which no trees may grow except in the most favorable localities. The redwood has been entirely eliminated and has survived only along the Pacific border, where summer fogs, combined with winter rains, provide a habitat sufficiently moist for this exacting tree.

The decrease in summer rainfall in western America has increased the number of trees with thick evergreen leaves and has reduced the representation of broad-leafed deciduous types. In such manner the forests of the eastern and western part of the United States, while arising at the same source and originally of the same composition, have come to bear distinctive characteristics.

The exhibit consisted of a collection of fossil leaves of fourteen species of trees. Next to each fossil leaf a modern leaf was placed showing clearly how little evolutionary change most of these species had undergone during a period of more than thirty million years. A four- to twelve-minute lecture, illustrated with lantern slides projected on maps showing the distribution of forests at different periods, was given at frequent intervals.

Protection and Use of a Primitive Natural Area at Point Lobos, California

The only remaining grove of Monterey cypress trees existing under primitive

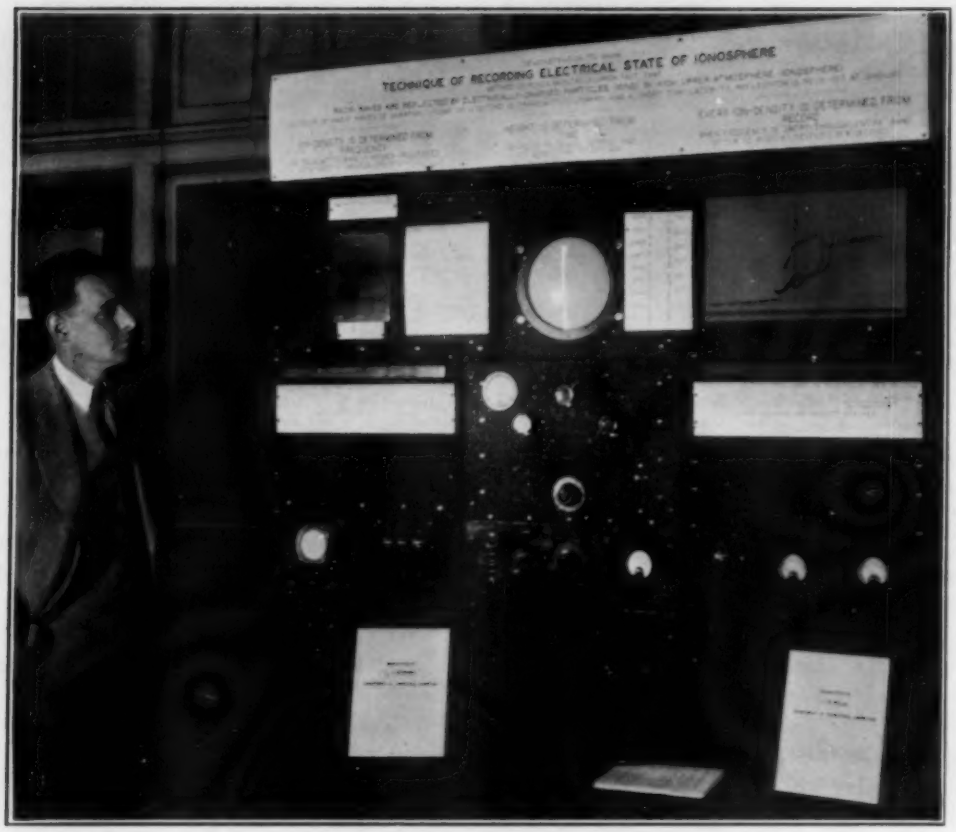


FIG. 2. AN ELECTRICALLY OPERATED PANEL
ILLUSTRATING THE RADIO-ECHO METHOD OF RECORDING THE ELECTRICAL STATE OF THE IONOSPHERE.

conditions is standing on a beautiful headland of the California coast near Monterey. In attempting to preserve this Point Lobos cypress grove it was necessary to have information regarding the contents of the grove and its environment. Exhaustive studies were made of the trees, all associated plants and animals, the soil, the rocks, the climate and the history of the region. Results of this study have been made the basis of the administration of the Point Lobos Reserve by the State of California.

The exhibit, prepared by N. B. Drury, of San Francisco, and Dr. R. W. Chaney, of the University of California, consisted of air photographs of the point, photographs of the groves and maps of the area.

Recent Cave Explorations in the Southwest

Caves have served as shelters for early man in America, and cavern deposits frequently contain evidence of man's occupancy. Remains of his fires, cultural objects and even skeletal parts make cave sites of special interest to the archeologist seeking to trace the history of man.

Specific sites containing evidence of man, animals and plants dating back in

time perhaps as much as 10,000 years are Shelter Cave, New Mexico, and Gypsum Cave, Nevada. In addition to facts bearing on the early history of man, a prevailing dry climate has brought about in some instances the preservation of the perishable parts of extinct animals not generally found in a fossil or subfossil record.

Explorations conducted in the lower Grand Canyon of Arizona under the auspices of the National Park Service have brought to light caves containing a remarkably well-preserved record of animal remains and in at least one instance an early Pueblo culture. The extinct ground sloth (*Nothrotherium*) is represented in the cavern accumulation not only by skull and skeletal parts, but also by dung, hide, hair, dried tissues and ligaments. Similarly preserved remains representing hoofed mammals and including apparently an extinct species of mountain goat (*Oreamnos*) have also been found. The occurrence has many points of similarity to the Gypsum Cave.

The exhibit prepared by Dr. Chester Stock, research associate of the Institution and professor of paleontology at the California Institute of Technology, showed skulls and skeletal parts, hide, hair and dung of various animals found in Rampart and Muav Caves in the lower Grand Canyon, in Smith Creek Cave and Gypsum Cave, Nevada, and Shelter Cave, New Mexico. Some specimens showed definite evidence of contact with heat or fire.

New Factors in Animal Metabolism

Metabolism signifies chemical changes proceeding continually in living cells, by which the energy is provided for the vital processes and activities, and new material is assimilated to repair the waste. When the body is relaxed and not actively digesting or absorbing food, the collective activity of the cells represents basal metabolism.

A long series of experiments revealed a significant difference in basal metabolism between different types of cattle and horses, types in which special functions had been developed to a high degree by selective breeding. The beef-cattle type, an energy conserver, has a low metabolism, while the dairy-cattle type, an energy secreter, has a high basal metabolism. Similarly, the draft horse has a low metabolism, while the race horse has a high metabolism.

In addition to the genetic factor responsible for the difference in metabolism another factor has been found. Experiments with cows indicated that the basal metabolism is highest in the spring, the percentage for different individuals ranging from 3 to 68 per cent. It is probably a significant fact that this seasonal effect, which appears to be independent of food intake, represents the highest general tissue stimulation during the period of longest and most intense sunlight. This contradicts the conception heretofore accepted that basal heat production is conditioned by the rate of heat loss.

The exhibit was prepared by Professor E. G. Ritzman, research associate of the Institution and a staff member of the New Hampshire Agricultural Experiment Station. It represents cooperative work with Dr. F. G. Benedict, of the Institution's Nutrition Laboratory at Boston. The exhibit consisted of charts with photographs of types of cattle and horses used in the experiments; data showing the number of calories used by these animals for different purposes; basal metabolism data; data on the influence of environment on metabolism; and photographs of apparatus used in the experiments.

Exploration of the Earth's High Atmosphere with Radio Waves

Rapid changes in the earth's magnetism, severe difficulties in long-range

FIG. 3. A PHOTO-ELECTRIC PHOTOMETER
USED AT MT. WILSON OBSERVATORY FOR MEASUREMENTS OF ABSORBING MATERIAL IN SPACE.

radio transmission and effects observed in other branches of science arise in the outer region of the earth's atmosphere, which extends from 40 to 400 miles. They arise because of important physical and photochemical reactions in the upper atmosphere produced by conditions on the sun.

To understand the nature of the relationship between the solar causes and the consequent terrestrial manifestations, knowledge of the outer atmosphere is essential. With this problem in view, the Department of Terrestrial Magnetism at Washington has developed an apparatus which continuously and automatically records the electrical state of the upper atmosphere throughout its extent.

When a wave of certain radio frequency is transmitted upward it is reflected in the upper atmosphere only when it reaches a region having a definite density of ions. The time involved for the waves to travel upwards and to return to the ground is a few ten-thousandths of a second. The new apparatus automatically sends out short pulses of radio waves and registers their echoes, while the radio frequency is changed during a period of fifteen minutes from about 500 to 16,000 kilocycles per second. This procedure is repeated throughout the twenty-four hours of the day, so that changes in amount and distribution of ionization with respect to height can be continually measured.

The exhibit prepared by Drs. L. V. Berkner and H. W. Wells consisted of the actual apparatus and an electrically operated panel illustrating the principles of its operation (Fig. 2).

ABSORBING MATERIAL IN SPACE

The universe as now known is a vast space approximately a billion light-years in diameter, in which galaxies are, on the whole, uniformly distributed. The galaxies are in general separated from each

other by distances of the order of ten to a hundred times their own diameter, so that only a very minute portion of space is occupied by them. A galaxy is a system made up of stars, millions of them, separated from each other by very large distances of tens of millions of times the diameter of a star.

Our sun is a member of one of these galaxies—the Milky Way. It is known from star counts in various directions that the Milky Way is roughly lens-shaped, with a diameter of perhaps 100,000 light years and a maximum thickness of something like one fifth to one tenth of this. The sun is at a considerable distance from the center but not very far from the median plane of the system.

The new knowledge about absorbing material in the space of our galaxy has contributed to this picture of the universe principally by reducing the inferred importance of our own system. At one time the Milky Way was considered large enough to contain all the nebulae. When these were determined to be independent external systems of stars, the Milky Way still held the predominant place and was thought to be perhaps five times as large in diameter as the next largest system. With the dimensions of our own galaxy revised on the basis of absorption to about one half the previous size, and the diameter of other galaxies found to be larger than were formerly measured, our own place in space is not nearly so unique as we formerly had good reason to believe.

At this exhibit Dr. Joel Stebbins, research associate of the Institution and director of the Washburn Observatory of the University of Wisconsin, demonstrated a photo-electric photometer with which measurements of absorbing material were made (Fig. 3). Dr. Sinclair Smith, of the Mt. Wilson Observatory of Carnegie Institution, demonstrated two models of galaxies, one of the Milky Way as it would look from a distance of 20,000 light years, and another a model of nine neighboring galaxies as they would look from a distance of two million light-years.

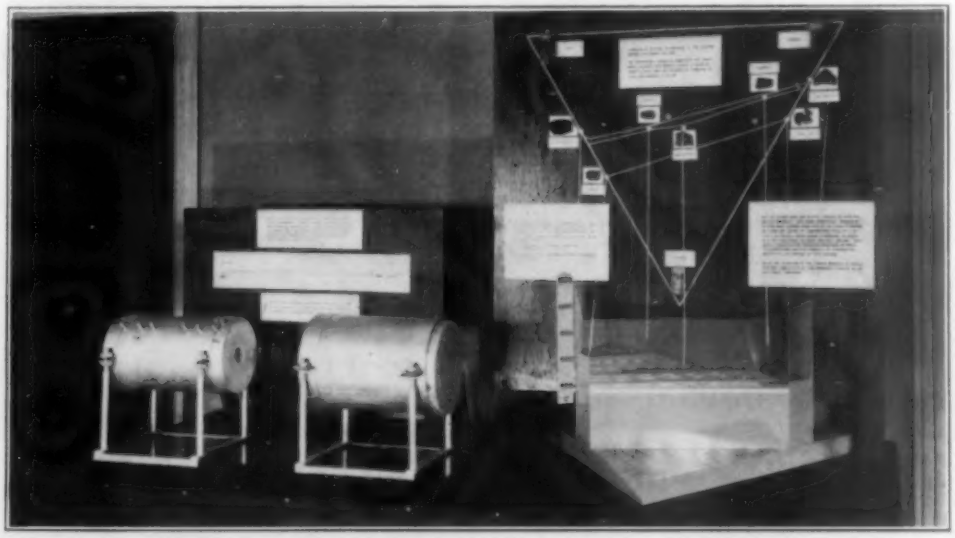


FIG. 4. THE SYNTHESIS OF ORES

FURNACES AND A TUBE USED AT THE GEOPHYSICAL LABORATORY FOR THE SYNTHESIS OF COPPER-IRON-SULFUR ORES, AND A CHART SHOWING THEIR PHYSICO-CHEMICAL INTER-RELATIONSHIPS.

Formation of Copper Ores

In many ore deposits throughout the world the indispensable element copper is associated with iron and sulfur. The elements are combined in a series of minerals; some of these minerals are found in large amounts in certain ore bodies, others are less common but still useful to students of ore deposits as clues to the occurrence of their more important relatives.

In nature the history of copper and iron sulfides goes back to volcanic and other phases of igneous activity. When the great bodies of igneous materials in the earth's crust cooled and crystallized, the sulfides of copper and iron separated from them more or less thoroughly. For many years the formation of ores has been studied intensively at the Geophysical Laboratory of Carnegie Institution at Washington, and as a result of these studies it is possible to prepare under defined conditions of temperature and pressure all the known natural copper-iron-sulfur minerals.

The exhibit prepared by Dr. H. E. Merwin, of the Geophysical Laboratory, consisted of ovens and tubes used in actual experiments; a generic chart of copper-iron-sulfur minerals indicating their interrelationships; and samples of these minerals (Fig. 4).

The Publications of the Institution

Since its inception the Institution has published the Year Book, of which the current issue constitutes the thirty-fifth volume of the series. These Year Books consist of comprehensive review of the current work of the various groups of investigators and a statement by the president explaining and interpreting the work of the Institution viewed as an organic whole.

Monographic series, with the first volume printed in 1903, record the results of large research projects. So far 687 volumes, aggregating 205,000 printed pages, have been published.

In order to disseminate interpretations of the scientific results among non-specialized readers as well as among scientists generally, the Institution has been publishing since 1926 the *News Service Bulletin*, the *Supplementary Publications Series* and the *Clip Sheet Service*.

Through the medium of the News Service Bulletin, articles dealing with important phases of current research and written in non-technical language are issued. The Supplementary Publication Series publishes the articles represented by lectures given under Institution sponsorship by staff members of the results of their investigations. The Clip Sheet Service is designed for the use of the press.

This exhibit consisted of a collection of various publications and especially those published during the current year.

POETRY AND ASTRONOMY

By Dr. FREDERICK W. GROVER

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Poets and prose writers alike make frequent use of material descriptive of the natural world around us. Joyous and festive occasions require for their proper setting beautiful landscapes, the song of birds, gently rounded cloud forms. Villainous deeds, on the contrary, are never so villainous as when nature connives with forked lightnings, the sighing of the tempest and the prowling of unclean beasts to show them in their proper guise.

The beauties of the sunset sky have taxed the powers of poet as well as painter. How natural that the aspects of the heavenly bodies, the sun, the moon and stars should also receive literary treatment! Here, however, many writers show that they are on unfamiliar ground. Their figures of speech are obvious: their coloring is crude. Others, on the contrary, have understood how to weave astronomical fact with mythological legend to produce a fabric harmonizing with the action of the story or the mood of the actors.

The author has been interested for some years in noting such astronomical references in poetry as have come to his notice, and, although such a method of survey is far from comprehensive, many striking and beautiful passages have come to his attention. From these have been selected for quotation in this article examples of the best of this type of writing, gems distinguished not for their form and intrinsic beauty alone, but for the accuracy of their statement and their harmony with their settings.

References to those poetical descriptions of the constellations which have come down to us from classical times are here purposely omitted, as well as passages from that able and accurate account of astronomical discovery which Alfred Noyes has given us in "Watchers of the Sky." Such works lie beyond the scope of this article, which is to deal with astronomical allusions in poetry rather than with treatises on descriptive astronomy in poetical form.

Quotations from certain other authors are here omitted, because, in the judgment of the author, their astronomical interest is negligible. For example, Shelley's works abound in descriptions of beautiful clouds and gorgeous sunsets, but the heavenly bodies are either merely mentioned or introduced in an artificial manner. Swinburne's astronomical references are vague and his figures mixed. In still other poems, as, for example, Lytton's "When Stars are in the Quiet Skies," all the astronomical content is to be found in the title, and the poem is a love-lyric pure and simple.

On the other hand, the works of certain other writers, and preeminently those of Dante, Milton and Tennyson, contain frequent passages which argue the possession by their authors of considerable astronomical knowledge. Quite naturally, therefore, extracts from these authors will here receive especial prominence.

References to the sun are of frequent occurrence and depict it in various aspects. In the words of the Psalmist, he "is like a bridegroom coming out of his chamber, and rejoiceth as a strong man to run a race." Appropriate to this aspect also is the well-known stanza from

Omar Khayyam, in which is pictured the paling of the stars at dawn and the first moments of the sunrise:

Wake! For the Sun who scattered into flight
The stars before him from the fields of night,
Drives night along with them from Heav'n, and strikes
The Sultan's turret with a shaft of light.

The sun is often identified with the sun-god of mythology, who daily drove his chariot across the sky, and at night returned to the east below the ocean's rim. Thus Milton wrote of the sunset and the passage of the sun below the horizon in the north,

And the gilded car of day
His glowing axle doth allay
In the steep Atlantic stream:
And the slope sun his upward beam
Shoots against the dusky pole,
Pacing toward the other goal
Of his chamber in the east.

In quite another guise the same author depicts the sun at its rising:

So when the sun in bed,
Curtained in cloudy red,
Pillows his chin upon an orient wave.

Longfellow appropriately introduces the rising sun on the wedding morning of John Alden and Priscilla in the form of a high priest of Israel. References to the vestments prescribed by the law of Moses are skilfully introduced.

Forth from the curtain of clouds, from the tent of purple and scarlet,
Issued the sun, the great High-Priest, in his garments resplendent,
Holiness unto the Lord, in letters of light on his forehead,
Round the hem of his robe, the golden balls and pomegranates,
Blessing the world he came, and the bars of vapor beneath him
Gleamed like a grate of brass, and the sea at his feet was a laver.

References to the sun in eclipse are frequent. The ancient superstitious awe, evoked by that phenomenon, is touched upon in the following lines from "Paradise Lost":

. . . as when the sun new-risen
Looks through the horizontal misty air
Shorn of his beams, or, from behind the moon,
In dim eclipse, disastrous twilight sheds
On half the nations, and with fear of change
Perplexes monarchs.

The total eclipse of 1820, which Wordsworth saw in Italy, inspired one of his poems. His description of the unearthly illumination, which those of us who saw the eclipses of 1925 and 1932 will never forget, has an authentic ring which other parts of the poem do not possess.

The sky an azure field displayed;
'Twas sunlight sheathed and gently charmed,
Of all its sparkling rays disarmed,
And as in slumber laid—

Or something night and day between,
Like moonshine, without shadow, spread
On jutting rock and curved shore,—

The origin of the zodiac, that belt of constellations which marks the apparent path of the sun among the stars during the year, antedates history. The old familiar figures, beginning with the Ram and ending with the Fishes, which greet the eye from every almanac, have caught the imagination of many a poet, and are used by them to fix the seasons. Thus, for example, Longfellow describes the advance of the autumn at the end of October in the words

Now had the season returned, when the nights grow colder and longer,
And the retreating sun the sign of the Scorpion enters;

and Dante refers to the turn of the Italian winter, at the end of January, in a stanza which suggests the uncertain weather which there accompanies the lengthening of the days:

In the year's early nonage, when the sun
Tempers his tresses in Aquarius' urn,
And now towards equal day the nights recede;
When as the rime upon the earth puts on

Her dazzling sister's image, but not long
Her milder sway endures:

In his "Poet's Calendar" Longfellow gives verses descriptive of all the signs, and in Thomson's "Seasons" especially fine use of them is made. Thus, for example, the short northern night, at the end of June, is described, when the sun leaves the sign of Gemini and enters Cancer. In England, at that time, the twilight persists practically the whole night.

When now no more the alternate Twins are fired,
And Cancer reddens with the solar blaze
Short is the doubtful empire of the night.

This contrasts vividly with his picture of the opposite period of the year. In northern latitudes the December sun attains only a small altitude all the day.

Now when the cheerless Empire of the sky
To Capricorn the Centaur-Archer yields
And fierce Aquarius stains the inverted year;
Hung o'er the farthest verge of heaven, the Sun
Scarce spreads o'er ether the dejected day.

As would be expected, the moon in all its aspects lends itself well to poetic description. Whittier describes the crescent phase in the words,

A young moon at its narrowest
Curves sharp against the darkening west.

In "The Blessed Damozel" of Dante Gabriel Rosetti occurs the figure:

the curl'd moon
Was like a little feather
Fluttering far down the gulf.

Longfellow in "The Masque of Pandora" likens the new moon to the scythe of Kronos, who finds his counterpart in the sky in the planet Saturn.

Blood-red, last night,
I saw great Kronos rise; the crescent moon
Sank through the mist, as if it were the scythe
His parricidal hand had flung far down
The western steeps.

Browning describes the everchanging phases of the moon, its waxing and its waning and its changing position in the sky, in the poem "One Word More."

Lo, the moon's self!
Here in London, yonder late in Florence,
Still we find her face, the thrice transfigured,
Curving on a sky imbrued with color,
Drifted over Fiesole by twilight,
Came she, our new crescent of a hair's breadth,
Full she flared it, lamping Samminiato,
Rounder 'twixt the cypresses, and rounder,
Perfect till the nightingales applauded.
Now, a piece of her old self, impoverished,
Hard to greet, she traverses the house roofs,
Hurries with unhandsome thrift of silver,
Goes dispiritedly—glad to finish.

Longfellow described the pale disk of the moon seen in daylight hours in the words,

In broad daylight, and at noon,
Yesterday I saw the moon
Sailing high, but faint and white
As a school-boy's paper kite.

And Tennyson in "The Lover's Tale" describes it still more aptly.

On the other side, the moon,
Half-melted into thin blue air, stood still,
And pale and fibrous as a withered leaf,
Not yet endured in presence of his eyes
To indue his luster;

The full moon rising and bathing the landscape in a flood of light is a favorite theme, and it is difficult to select from the abundance of references examples which shall be representative. The following is from Thomson's "Autumn":

Now through the passing cloud she seems to stoop
Now up the pure Cerulean rides sublime.
Wide the pale Deluge floats, and streaming mild
O'er the skied mountain to the shadowy vale,
While rocks and floods reflect the quivering gleam
The whole air whitens with a boundless tide
Of silver radiance, trembling round the world.

Contrast this with a reference to the fact that the full moon blots out all but the brightest stars in a well-known passage from Wordsworth's "Intimations of Immortality."

The Moon doth with delight
Look round her when the heavens are bare;

Many beautiful passages refer to the moon in her rôle of the goddess Cynthia or Diana. How delicately, yet how vividly, these lines from Spenser's "Epithalamium" call to mind a night when the moon is at the full, and is consequently above the horizon from sunset to sunrise.

Who is the same, which at my window peepes?
Or whose is that fair face that shines so bright?
Is it not Cinthia, she who never sleepes,
But walks about high heaven all the night.

Quite different, but graceful also, is Ben Jonson's "Ode to Diana" which begins with the stanza:

Queen and huntress, chaste and fair,
Now the sun is laid to sleep,
Seated in thy silver chair
State in wonted manner keep:
Hesperus entreats your light,
Goddess excellently bright.

Of the planets bright Venus has especially inspired the poets. As morning-star it was known to the ancients as Phosphor or Lucifer, and as evening-star as Hesperus or Vesper, before it was realized that a single body was appearing in a dual rôle. This is referred to by Tennyson in "In Memoriam."

Sweet Hesper-Phosphor, double name,
For what is one, the first, the last,
Thou like my present and my past,
Thy place is changed; thou art the same.

References to the morning-star are generally of a joyous nature. In the book of Job we read that "the morning-stars sang together." It is the herald of the dawn, whose office it is to dismiss the other stars before the rising of the sun. In Milton's poem "On the Morning of Christ's Nativity" occurs the stanza:

The stars with deep amaze,
Stand fixed in steadfast gaze,
Bending one way their precious influence.
And will not take their flight,
For all the morning light
Or Lucifer that often warned them thence;
But in their glimmering orbs did glow,
Until their Lord himself bespake, and bid them go.

and in Tennyson's "Maud" occurs an especially fine treatment of the coming of the dawn.

For a breath of the morning moves,
And the planet of Love is on high,
Beginning to faint in the light that she loves,
On a bed of a daffodil sky,
To faint in the light of the sun she loves,
To faint in his light,—and to die.

There is a wealth of material having to do with Hesperus, the evening star. Wolfram's "Ode to the Evening-Star" in "Tannhaeuser" springs at once to mind. A whole section of Thomas Campbell's poem "Caroline" is dedicated to the evening-star. Of this poem, in which the star comes out a poor second to Caroline, the following is perhaps best worth quoting in this connection:

Gem of the crimson-colored Even,
Companion of retiring day,
Why at the closing gates of Heaven,
Beloved star, dost thou delay?

Akenside also composed a florid "Ode to the Evening-Star," which begins:

Tonight retired the queen of heaven
With young Endymion stays:
And now to Hesper is it given
Awhile to rule the vacant sky,
Till she shall to her lamp supply
A stream of brighter rays.

Most frequently reference is made to the brief splendor of the star in the twilight sky which ushers in the night, as is illustrated in "Paradise Lost."

The sun was sunk, and after him the star
Of Hesperus, whose office is to bring
Twilight upon earth, short arbiter
'Twixt day and night, and now from end to end
Night's hemisphere had veiled the horizon round.

Effective use of the star is also made to suggest a mood of sadness. For example,

in Tennyson's "In Memoriam" occurs the passage:

> Sad Hesper o'er the buried sun
> And ready, thou, to die with him,
> Thou watchest all things ever dim
> And dimmer, and a glory done.

The remaining planets, with the exception of Mars, have received scant poetical mention. Thomson, it is true, wrote of the solar system as a whole (bounded by Saturn in his day):

> from the far bourne
> Of utmost Saturn, wheeling wide his round
> Of thirty years, to Mercury, whose disk
> Can scarce be caught by philosophic eye,
> Lost in the near effulgence of thy blaze.

As he accurately states, Mercury is seldom seen except by the astronomers. Saturn, although fairly bright, is not readily distinguished among the other brighter stars. It seems strange, however, that Jupiter has not received some poetic notice. For months at a time, every year, it is the brightest of the stars of the night sky and is not greatly excelled in brightness by Venus. Mars, on the contrary, although it is inconspicuous except for a few weeks every other year, has gained some mention among the poets, probably because of its fiery red color and the warlike associations of its name.

In Longfellow's poem, "The Light of Stars," "the first watch of the night is given to the red planet Mars." In Dante's "Inferno" occurs the passage

> And now, behold! as at the approach of morning,
> Through the gross vapors, Mars grows fiery red
> Down in the west upon the ocean floor.

An interesting reference to Mars from a historical point of view is found in Tennyson's "Maud."

> She seemed to divide in a dream from a band of the blest,
> And spoke of a hope for the world in the coming wars—
> "And in that hope, dear soul, let trouble have rest,
> Knowing I tarry for thee," and pointed to Mars
> As he glowed like a ruddy shield on the Lion's breast.

The reference is to the entry of England into the Crimean War, 1854–55. Calculation shows that Mars came to opposition (maximum brightness) in the spring of 1853 in the constellation of the Lion close to Regulus, the bright star which marks the heart of the Lion.

The starry heavens themselves have inspired a variety of poetic images. Longfellow in "Evangeline" likens the stars to "the forget-me-nots of the angels," and farther on in the same poem to "the thoughts of God in the heavens." In "Sandalphon" he gives a moving description of the beauties of a clear, moonless night in the lines:

> When I look from my window at night,
> And the welkin above is all white,
> All throbbing and panting with stars.

In the so-called Greek Hymn the stars are themselves angels, and so are they named in Lowell's "Rosaline."

> The stars came out; and one by one,
> Each angel from his silver throne
> Looked down and saw what I had done.

References to the Milky Way are summarized in Longfellow's "Galaxy." From this may be quoted a passage which contrasts the usual, the classic connection of the Galaxy with the legend of Phaeton with a conception which is all the poet's own.

> Nor this I see, nor yet the ancient fable
> Of Phaeton's wild course, that scorched the skies
> Where'er the hoofs of his hot coursers trod;
> But the white drift of worlds o'er chasms of sable,
> The star-dust, that is whirled aloft and flies
> From the invisible chariot-wheels of God.

The silent, unhastening, ceaseless march of the stars from their rising to their setting lends itself well to the mark-

ing of the passage of time for the poets as well as for the astronomers. In Dante's great work the transition from one episode to another is often effected by the interpolation of a passage describing the positions of certain constellations, for example, the interpolation at the end of Canto XI of the Inferno:

> . . . for now
> The Pisces play with undulating glance
> Along the horizon, and the Wain lies all
> O'er the northwest; and onward there a space
> Is our steep passage down the rocky height.

This aspect of the sky corresponds to a time about two hours before the sunrise on April 9 (the date of Good Friday in 1300.)

In "Cassandra Southwick" Whittier gives a picture of hours spent in weariness of spirit.

> Last night I saw the sunset melt through my
> prison bars,
> Last night across my damp earth-floor fell the
> pale gleam of stars:
> In the coldness and the darkness, all through the
> long night-time
> My grated casement whitened with the autumn's
> early rime.
> Alone in that dark sorrow, hour after hour crept
> by,
> Star after star looked palely in and sank adown
> the sky.

Frequent and effective use is made of a figure of speech, borrowed from the classical writers, which supposes the sun, moon and stars to rise from the sea and to be bathed, at their setting, in the waves of the western ocean, at the confines of the world. For example, in Tennyson's stirring poem "Ulysses" the ageless hero exhorts his comrades in the words:

> Come, my friends,
> 'Tis not too late to seek a newer world.
> Push off, and sitting well in order smite
> The sounding furrows: for my purpose holds
> To sail beyond the sunset, and the baths
> Of all the western stars, until I die.

It is generally conceded that the constellations date back to about 3000 B.C. To two of the classical writers, Aratus and Manilius, we owe full descriptions of them, together with accounts of their reputed influence on the weather and the connection of the times of appearance of certain of them with the times of sowing and reaping. The works of these authors, taken with the records of the positions of the brighter stars made by Ptolemy from his measurements, make it certain that the constellations are essentially unchanging through the centuries. The contrast between this fixity of the skies above us and the ephemeral nature of our lives and fortunes has often been made the theme of poetry. As an instance of this may be quoted that familiar passage from Omar Khayyam, which has been so effectively set to music in Lisa Lehmann's "Persian Garden":

> Yon rising moon that looks for us again—
> How oft hereafter will she wax and wane;
> How oft hereafter rising look for us
> Through this same garden—and for *one* in vain!

The same theme underlies also the following from "Lucifer and Elissa" by Philip James Bailey:

> . . . nigh one year ago,
> I watched that large bright star, much where it
> is now!
> Time hath not touched its everlasting lightning,
> Nor dimmed the glorious glances of its eye,
> Nor passion clouded it, nor any star
> Eclips'd: it is the leader still of heaven.
> And I who lov'd it then can love it now;
> But I am not what I was, in one degree.

Certain of the star groups and the brighter individual stars find mention in the works of many authors. Among them the stars Arcturus and Sirius, the two star clusters of the Pleiades and the Hyades, the constellations of Orion, the Greater Bear and the Smaller Bear are those most often cited. Thus, in the Book of Job, we find the passage, "Canst thou bind the sweet influences of the Pleiades, or loose the bands of Orion? Canst thou bring forth Mazzaroth (the signs of the

zodiac) in his seasons? Or canst thou guide Arcturus with his sons?"

The constellations of the Bears never set in northern latitudes but circle endlessly about the pole. This fact is referred to in the following quotation from the Odyssey:

So he sat and cunningly guided the craft with the helm
Nor did sleep fall upon his eyelids as he viewed
The Pleiades and Boötes, that setteth late, and
The Bear, which they likewise call the Wain, which
Turneth ever in one place and alone hath no
Part in the baths of Ocean.

In "Balder Dead" Matthew Arnold writes in a similar vein:

But he must ever watch the Northern Bear,
Who from her frozen heights with jealous eye,
Confronts the Dog and Hunter in the south,
And is alone not dip't in Ocean's stream.

And in "Prometheus" Lowell has produced a beautiful sequence of astronomical figures:

The Bear, that prowled all night about the fold
Of the north-star, hath shrunk into his den,
Scared by the blithesome footsteps of the Dawn,
Whose blushing smile floods all the Orient;
And now bright Lucifer grows less and less
Into the heavens' blue quiet deep-withdrawn.

The practically fixed position of the pole-star in the sky and its usefulness in navigation is referred to in the following passage by William Cullen Bryant.

On thy unaltering blaze
The half-wrecked mariner, his compass lost,
Fixes his steady gaze,
And steers undoubting to the friendly coast;
And they who stray in perilous wastes by night
Are glad when thou dost shine to guide their footsteps right.

The lines which Lowell puts into the mouth of Columbus liken the star to a lighthouse:

This have I mused on, since mine eye could first
Among the stars distinguish and with joy
Rest on that God-fed Pharos of the north,
On some blue promontory of heaven lighted
That juts far out into the upper sea.

The constellation Orion, the most conspicuous in the sky, forms the subject of the poems "The Occultation of Orion," by Longfellow, "Singing Stars," by Arthur Reed Ropes, and "Orion," by Charles Turner. Tennyson in "Maud" showed his familiarity with the constellation in the beautiful and accurate picture which he drew of the western sky in the month of May.

For it fell at a time of year
When the face of the night is fair on the dewy downs,
And the shining daffodil dies, and the Charioteer
And starry Gemini hang like glorious crowns
Over Orion's grave low down in the west.

Effective emphasis of the distance which separates us from those living in the Antipodes is afforded by references to the differences of their seasons from our own and the changed aspect of the sky seen in southern latitudes. In "The Brook," by Tennyson,

Katie walks
By the long wash of the Australasian seas
Far off, and holds her head to other stars,
And breathes in converse seasons.

South of the equator our pole star is continually below the northern horizon, while the famous Southern Cross circles about the region where a few faint stars mark the south pole of the heavens. These differences are used with telling effect in a poem by Housman entitled "Astronomy":

The Wain upon the northern steep
Descends and lifts away.
Oh I will sit me down and weep
For bones in Africa.

For pay and medals, name and rank,
Things that he has not found,
He hove the Cross to heaven and sank
The pole-star underground.

And now he does not even see
Signs of the nadir roll

> At night over the ground where he
> Is buried with the pole.

However, perhaps the most remarkable reference to the Southern Cross to be found in the literature occurs in Dante's "Purgatorio." After having discussed with his guide and mentor the to him unfamiliar motion of the sun from right to left in the northern sky, brought about by their position south of the equator, Dante, a little farther on, refers to the aspect of the night sky:

> To the right hand I turn'd, and fixed my mind
> On the other pole attentive, where I saw
> Four stars ne'er seen before save by the ken
> Of our first parents. Heaven of their rays
> Seem'd joyous. O thou northern site bereft
> Indeed, and widow'd, since of these deprived.

The reference to the four stars of the Cross is unmistakable. When the constellations were first named, millenniums before the Christian era, the Southern Cross was visible in the north temperate zone, but the slow precession of the earth's axis, during the centuries, has brought about great changes in the positions of the poles among the stars. The Southern Cross is now always below the horizon, except for places in the tropics and the southern hemisphere, and such was the case also in Dante's time.

The poetic quotations thus far considered all relate to what may be termed the astronomy of the ancients, that is, the astronomy of the millenniums before the invention of the telescope and the application of exact measuring instruments to the study of the sky revolutionized astronomical progress. For the most part, the astronomical figures found in the works of modern poets with their mythological allusions are merely variants of those used by the classical writers, and this is quite appropriate. In spite of the existence of astronomical observatories, most of us continue to view the beauties of the sky without optical aid, as did our forefathers, and like them take pleasure in the legends associated with the heavenly bodies. It is popularly believed, indeed, that exact science and poetry are mutually exclusive in any work, and it is true, of course, that scientific books make little or no use of the medium of poetry in imparting knowledge. Certain poets, however, have been so successful in combining scientific accuracy with beauty of diction as to argue for them the possession of a knowledge of astronomical science. Examples have already been given which indicate that Dante was well versed in the astronomical lore of his time. In "Paradise Lost" are to be found many passages in which the astronomical ideas of the Copernican theory, which was becoming firmly established in Milton's time, are compared with those of the older, artificial Ptolemaic system, which dealt with a celestial sphere

> With Centric and Eccentric scribbled o'er
> Cycle and Epicycle, orb in orb.

In the same work Uriel is made to argue the merits of the two systems at some length. That the discoveries of Galileo with his newly invented telescope were well known to Milton is evidenced by the passage in which he describes Satan's shield:

> The broad circumference
> Hung on his shoulders like the moon, whose orb
> Through optic glass the Tuscan artist views
> At evening, from the top of Fesolé
> Or in Valderno, to descry new lands,
> Rivers, or mountains, in her spotty globe.

Until modern times, the apparition of a comet suddenly appearing out of the nowhere was believed to presage the death of some important personage or some other dire calamity. Shakespeare voices that belief in "Julius Caesar":

> When beggars die, there are no comets seen;
> The heavens themselves blaze forth the death of princes.

A comet which appeared in 1066 was afterward believed to have foretold the

Norman Conquest. In the poem "Harold" Tennyson represents Morcas as saying,

"Lord Leodwin, dost thou believe that these
Three rods of blood-red fire up yonder mean
The doom of England and the wrath of heaven?"

The comet of 1456 preceded the deposition and subsequent execution of the unfortunate Henry VI. This event probably suggested the following lines from Shakespeare's drama of that name:

Comets, importing change of times and states
Brandish your crystal tresses in the sky;
And with them scourge the bad, revolting stars
That have consented unto Henry's death.

The English astronomer, Halley, reasoning from the similarity of the calculated orbits, dates of appearance and recorded aspects of certain remarkable comets of the past, came to the conclusion that the great comet of 1682 would return in 1758. Actually, the comet reappeared only a few months later than the predicted date, but more than twenty years after the death of Halley. It was this same comet, whose elongated elliptical orbit is well known to present-day astronomers which was given such publicity in 1910. That the verification of Halley's prediction made a deep impression on the poet Thomson is evident from a number of passages of which the following is perhaps the best:

Lo! from the dread immensity of space,
Returning with accelerated pace,
The rushing comet to the sun descends:
And, as he shrinks below the shading earth,
With awful train projected o'er the heavens
The guilty nations tremble.

Contrast this with the verses previously quoted above. The element of fear is still retained, but the rapid increase in the velocity of the comet as it approaches the sun, a characteristic of motion in an elongated elliptical orbit, as well as the very close approach of the comet to the sun are skilfully treated.

In the last century, Longfellow, and still more so, Tennyson, give evidence that they were interested in the progress of science. In "Locksley Hall" Tennyson probably referred to this when he wrote,

Here about the beach I wandered, nourishing a youth sublime
With the fairy tales of science, and the long result of time.

Browning, in general, discloses no such interest, but in "One Word More" he makes ingenious use of the fact that the moon constantly keeps the same face turned toward us, the other side being perpetually invisible from the earth.

What, there's nothing in the moon noteworthy?
Nay—for if that moon could love a mortal,
Use to charm him (so to fit a fancy)
All her magic ('tis the old sweet mythos)
She would turn a new side to her mortal,
Side unseen of herdsman, huntsman, steersman—
Blank to Zoroaster on his terrace,
Blind to Galileo on his turret,
Dumb to Homer, dumb to Keats—him, even!

And a few lines farther on,

God be thanked, the meanest of His creatures
Boasts two soul-sides, one to face the world with,
One to show a woman when he loves her.

The discovery of the planet Neptune in 1846 as a result of a mathematical study of perturbations of the motion of the planet Uranus, inspired, no doubt, the following passage from Longfellow's "Haunted Houses":

These perturbations, this perpetual jar
Of earthly wants and aspirations high,
Comes from the influence of an unseen star,
An undiscovered planet in our sky.

The lines of Keats,

Then felt I like some watcher of the skies
When a new planet swims into his ken,

refer to the discovery of Uranus, in 1781, an event resulting not from diligent theoretical investigation, but from Herschel's tireless telescopic exploration

of the sky. The wording is a little fanciful, since the newly found object was not at first recognized for what it was, so little did he or any one else suspect the existence of undiscovered planets.

In "Christus: A Mystery," Longfellow concisely and accurately refers to the double stars, stars which appear so close together in the sky that telescopic aid is necessary to see them separated.

> Nor let the Historian blame the poet here,
> If he perchance misdate the day or year,
> And group events together, by his art,
> That in the Chronicles lie far apart;
> For as the double stars, though sundered far,
> Seem to the naked eye a single star,
> So facts of history, at a distance seen,
> Into one common point of light convene.

The same poet, in "Charles Sumner," makes effective use of the fact that the stars are so distant that the light leaving the star at any moment does not reach the earth until years later.

> Were a star quenched on high,
> For ages would its light
> Still traveling downward from the sky
> Shine on our mortal sight.
>
> So when a great man dies
> For years beyond our ken
> The light he leaves behind him lies
> Upon the paths of men.

The question whether life exists on other planets of our solar system besides the earth will probably never be certainly answered. In the light of the evidence available, astronomers believe that Mars and Venus only may offer conditions not wholly inhospitable. From those planets the earth must appear as a star of much the same brightness as Venus appears to us. Tennyson, in "Locksley Hall Sixty Years Later," has ingeniously introduced these facts in the following passage:

> Venus near her! smiling downward at this
> earthlier earth of ours
> Closer on the sun, perhaps a world of never
> fading flowers.
> Hesper, whom the poet call'd the Bringer home
> of all good things.
> All good things may move in Hesper, perfect
> peoples, perfect kings.
> Hesper—Venus—were we native to that splendor or in Mars,
> We should see the Globe we groan in, fairest of
> their evening stars.
> Could we dream of wars and carnage, craft and
> madness, lust and spite
> Roaring London, raving Paris, in that point of
> peaceful light?
> Might we not in glancing heavenward on a star
> so silver-fair,
> Yearn and clasp the hands and murmur, "Would
> to God that we were there?"

The famous cluster of stars which bears the name of the Pleiades has been an object of interest since the earliest times. Every one can make out six stars, and some people three or four more. Galileo with his tiny telescope was able to see forty-five stars; large telescopes bring out hundreds. The surprising fact, however, is that when, first, photographs of the cluster were taken in the eighties of the last century, it was discovered that the stars are involved in an extended mass of nebulosity, that is, in a misty, ill-defined cloud of

> white nebulous matter between stars,
> Which, if not light, at least is likest light,

as Philip James Bailey so aptly describes it. A particularly happy description of the Pleiades, suggesting both the clustering stars and the nebulous cloud in which they are involved, is found in "Locksley Hall":

> Many a night I saw the Pleiades, rising through
> the mellow shade,
> Glitter like a swarm of fireflies tangled in a
> silver braid.

In "The Golden Year" Tennyson refers to the motion of the sun through space, a motion which is taking it, together with the planets which revolve

around it, toward the constellation of Hercules.

> We sleep and wake and sleep, but all things move;
> The Sun flies forward to his brother sun;
> The dark earth follows wheel'd in her ellipse:

In "The Princess" occurs a passage inspired by the Nebular Hypothesis of Laplace. This hypothesis postulates the evolution of the stars from nebulous matter as a result of eddying motion and condensation resulting from it. Continued motion and further condensation cause the planets to be thrown off from the nascent suns. The quotation referred to is as follows:

> This world was once a fluid haze of light,
> Till toward the center set the starry tides,
> And eddied into suns, that wheeling cast
> The planets: then the monster, then the man.

And in his "Epilogue" occurs a stanza which embodies the modern idea of island universes, that is, of the existence of not one but many universes, our own the Galaxy, and the others visible to us as spiral nebulae.

> The fires which arch this dusky dot—
> Yonder myriaded-worlded way—
> The vast sun-clusters' gathered blaze,
> World isles in lonely skies,
> Whole heavens within themselves.

The progress of science has never been so rapid as during the generation which has elapsed since the Victorian era: astronomical research has won for us a widely increased and ever growing knowledge of the starry heavens. However, to the best of the writer's knowledge, no poet has drawn inspiration from these new marvels, nor allowed his fancy to roam over this virgin field. Yet it would be a fascinating task, and one demanding no mean ability, to picture the whirl of the spectroscopic binaries, and the rhythmic oscillations of the Cepheid variables, to describe the individualities of the dwarf and giant stars, or to soar in imagination to the confines of an expanding universe.

THE BEGINNINGS OF HISPANO-INDIAN SOCIETY IN YUCATAN

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Factors Affecting Colonial Policy

Spanish colonial policy in America developed naturally from two basic factors: (1) conditions within the areas that were conquered and (2) the ideals and aims of the Spanish monarchy in the sixteenth century.

Although the Spanish colonies were for the most part within the tropical and sub-tropical zones, they contained large areas suitable for European settlement. Colonists in considerable numbers migrated to specially favored regions in New Spain and Peru, where they engaged in farming, stock raising, mining and trade. But the Spaniards found most of these areas already occupied by a numerous aboriginal population with highly developed civilizations based on an advanced agricultural economy. In this respect Hispanic America contrasted rather sharply with the temperate zones in which the British colonies in North America were founded, for the vast expanse of what is now the United States was lightly populated and the Indians were much less strongly rooted to the soil than those of Mexico, Guatemala and Peru. The British were able, therefore, to deal with the Indian tribes as independent units, as nations outside their own colonial system, whereas Spain was forced to incorporate them as an integral part of colonial society. Thus social evolution in Hispanic America has been characterized by the interaction and partial fusion of two races, and two sets of culture patterns, European and aboriginal.

The forces which influenced the formulation of policy dealing with the aborigines and their relations with the Spanish colonists were economic and religious, selfish and humanitarian. The original impelling motive of discovery and colonization was economic, and the exploitation of the resources of the colonies for the benefit of the Crown and of the colonists who supported the imperial system always remained the paramount factor in determining the character of administration. But the long crusade against the Moors had identified the cause of Catholic orthodoxy with national interests, and a militant zeal for the faith inspired the Spanish nation. It was inevitable, therefore, that when the Indies were conquered, the conversion of the aborigines and the extirpation of the older pagan religion and ceremonial should become one of the dominant aims of empire. Moreover, the Spanish jurists of the sixteenth century were inspired by a broad humanitarianism and an increasing interest in the relations between nations and peoples. The question of the aborigines raised important problems of theoretical and practical justice and the influence of the jurists contributed much to the formulation of legislation for the preservation of the liberties of the Indians within the limits imposed by the introduction of a new faith and the maintenance of Spanish supremacy.

The attempt to combine the economic and the ecclesiastico-humanitarian motives of empire created problems of tremendous historical significance. The Crown was obliged to recognize the demands of the colonists for the right to exploit Indian lands and labor, but it sought to limit abuses by protective legislation that would preserve at least the

legal status of the Indians as free beings and prevent the total expropriation of Indian property. It sought also to ensure the conversion of the Indians to the Christian faith, at the same time preserving the traditional folk culture in so far as it did not conflict with Christian standards of morals and orthodoxy. Hispanic America became in effect a sociological laboratory where experiments in human relationships were made on a vast scale. The final result was the creation of a Hispano-Indian society characterized by the domination of the masses by a small privileged minority, the hybridization of culture and the existence of unsolved problems of land and labor.

The History of Yucatan project sponsored by the Carnegie Institution of Washington is a part of its larger program of Maya research. Although the specific aim of the investigations in the post-conquest history of the Maya is to give unity to the researches of the specialists in Maya archæology on the one hand, and the descriptive studies dealing with modern folk culture in Yucatan on the other, these investigations become in reality a case study for the illustration of those problems of Hispanic-American social history that are derived from the conflict and fusion of cultures. The Carnegie Institution has made it possible to carry on the necessary spade work in the unpublished documentary sources in the archives of Spain and America, and it is hoped that the program, when completed, will provide a detailed analysis of Spanish colonial administrative processes as well as of theoretical policy and legislation in this important area.

The Hispano-Indian Government

The basic pattern of Hispano-Indian society in Yucatan was clearly marked out by the end of the sixteenth century or about sixty years after the conquest. By that time a new ruling caste of foreign origin, extremely jealous of its privileges, had obtained firm control over the destinies of the Maya race; the exploitation of Indian labor for the benefit of this caste had become an important problem of interracial relations; and a considerable amount of fusion of culture, especially in the realm of religion, had taken place. During the remainder of the colonial period these basic problems of provincial society remained essentially the same. The methods of exploitation of Indian labor changed according to the needs of the ruling class. The proportion of Christian and pagan elements in the total content of belief and ceremonial by which the Indians made their adjustments with the invisible world varied from place to place and from time to time. But there was no essential change in the fundamental character of Hispano-Indian society.

Several centuries prior to the Spanish conquest the Maya of Yucatan had established a measure of political unity. However, rivalry between the chieftains had caused the disintegration of central authority, and at the opening of the sixteenth century Yucatan was divided into a number of petty states or cacicazgos which frequently engaged in interstate warfare. Political leadership within each state tended to be concentrated in the hands of a ruling family, such as the Xius in Mani or the Cocoms in Sotuta. The unifying forces were cultural rather than political—a common language and a common fund of folk tradition.

The Spanish conquest destroyed the independence of these states and reestablished territorial and political unity within Yucatan, but the reins of government were held henceforth by an alien race. Supreme political and military authority was exercised by the Spanish governors appointed by the Crown. Subordinate to the governors were various local officers and the governing councils of the Spanish towns.

A measure of self-government was retained by the Maya in the Indian vil-

lages where local affairs continued to be controlled by native officers. In the beginning the Spanish authorities recognized the claims of former native lords and lesser nobles, and retained them as governors and principales of the pueblos. Moreover, during the sixteenth century certain chieftains even continued to exercise some leadership over areas that approximated the former petty states. But in the course of time the old rulers and their direct descendants were gradually removed from positions of influence and leadership.

This does not mean that the former ruling families lost all their old prestige. The Xius, for example, were recognized as having noble rank, and they obtained certain concessions and privileges, such as exemption from tribute, free labor on their farms and the right to possess firearms. They were also able to retain considerable holdings of land. But their influence as political and cultural leaders of the race was at an end.

The Ruling Caste

The real governing class in Yucatan subsequent to the conquest was a group of about 125 families, made up of conquerors, first settlers and their descendants. Members of this group held most of the subordinate provincial offices, and they dominated the city councils of Merida, Campeche and Valladolid, membership in which could be purchased and held for life. Control of the local councils gave the conquerors and their descendants the means for resisting measures limiting their vested rights. They were frequently able also to force the provincial governor or the defender of the Indians to abandon policies for the amelioration of abuses of native labor and other reforms detrimental to the interests of the ruling caste. Occasionally a provincial governor would try to strengthen his own position by the appointment of relations or personal retainers to local offices, but the conquistador caste would immediately present a forceful protest to the Crown and would usually be upheld. Special claims were also made on behalf of younger sons for preference in appointments to curacies in Indian towns and to offices in the cathedral of Merida.

In so far as possible the conquistadores sought to keep their blood clean, at least the line which inherited property. A few formally contracted marriage with Indian women, but most of the unions between the two races were extramarital. Mestizo children born out of wedlock were sometimes legitimized, but the ruling caste used all its influence to prevent them from holding office.

Encomiendas

The most important privilege granted to the conquerors and their descendants in all parts of the Indies was preference in appointment to encomiendas. During the first half of the sixteenth century an encomienda grant was essentially the right to use the labor of a stated group of Indians without pay. But this led to such abuses that a fixed tribute usually payable in kind was introduced in lieu of service, with the result that the encomiendas became a form of pension. The encomenderos were always able, of course, to obtain a considerable amount of labor from their Indians by extra-legal means, but subsequent to 1550 the essence of the system was tribute.

In return for the tribute payments the encomenderos were supposed to assume responsibility for the indoctrination of their Indians, but this obligation became a mere formality in so far as personal assistance in the missionary program was concerned. The most important obligation imposed by a grant of encomienda was military service, and in Yucatan the encomenderos were frequently called upon to defend the coasts or the port of Campeche against foreign corsairs. Grants of encomienda were made for two

lives or generations, but a third life was usually permitted by dissimulation on the part of the governing officials.

In Mexico proper, *i.e.*, in the area northwest of the Isthmus of Tehuantepec, about 55 per cent. of the Indian pueblos were held in encomienda, the remaining 45 per cent. paying tribute to the Crown. In Yucatan more than 90 per cent. of the towns were granted as encomiendas. This fact may be explained by the limited resources of Yucatan and the lack of opportunity for profitable enterprise other than agriculture. There were no mines; trade was limited mostly to dealings in those very native products of which the tribute payments were comprised, *viz.*, cotton cloth, maize, poultry and wax. In the sixteenth century grants of encomienda were practically the only means available for gratifying services performed during the conquest or for attracting new settlers to the province.

It is not surprising, therefore, that there was keen rivalry for appointments to encomiendas, that the tendency of a governor to fill vacancies by choosing new arrivals in preference to members of the old families was always bitterly resisted, or that protests were made against every attempt by the Crown to bring the system to an end. Grants of encomienda continued to be made until 1785, when the Crown finally ordered all tributes to be paid into the treasury, but even then payments continued to be made to former holders of encomiendas during the remainder of their lives.

Value of Tribute Required

The value of the encomienda tributes varied considerably from time to time. In the beginning the levies were based on the number of married males, with certain exceptions for persons who enjoyed freedom from tribute for one reason or another, but in the 1580's unmarried and widowed adults were also included in the matriculas or tribute rolls, with an assessment of one half the amount paid by a married person. The tributes were payable in kind. At first a large variety of articles, such as cotton cloth, maize, poultry, wax, honey, salt, fish, pottery, chile, beans, etc., were included in the village assessments, but by the end of the sixteenth century only three staples were required, *viz.*, cotton cloth, maize and poultry. In 1606 each married tribute payer was assessed about six square yards of cotton cloth, about 150 pounds of maize, one turkey and one chicken annually. There was also a considerable variation in prices between 1540 and 1600. The full unit of assessment during this period seems to have been worth amounts varying from twenty-three to thirty-six reales, depending on prices and the amount of goods payable annually. The 1606 assessment was worth thirty-one reales, or three and seven eighths silver pesos.

It is difficult to make an estimate of the value of the annual tribute payments in terms of modern currency. Any true estimate would depend upon the purchasing power of the old Spanish silver peso as compared with that of the modern Mexican peso. Maize prices probably provide the best basis for estimating purchasing power, and it appears that in 1606 the Spanish peso would buy at least four or five times as much maize as the present Mexican peso. On this basis the value of the annual tribute assessment for each married tribute payer in 1606 was 15.5 to 19.4 pesos in terms of modern purchasing power.

A conservative estimate of the value of encomienda tributes in 1549 would be 210,000 pesos. In 1606 they amounted to approximately 160,000 pesos. The largest encomienda in 1606 produced a gross revenue of 6,200 pesos, and the smallest 155 pesos. The average gross revenue was about 1,350. These sums should be multiplied by four or five to give the approximate purchasing power in Mexican pesos at present. The aver-

age gross income of about 1,350 pesos was a very generous sum, especially if we compare it with the governor's salary of 1,000 gold pesos or about 1,600 in silver.

The average wage for unskilled Indian labor was probably not more than one half a real or one sixteenth of a peso per day. For example, in 1553, the clergy and the city council of Merida agreed to fix wages at the following schedule: (1) two reales a week plus food for ordinary labor; (2) four reales a month for house servants or permanent employees receiving food and clothing; (3) twenty grains of cacao a day for porters carrying maize to Merida, a day's journey to be counted as five leagues. At current prices in 1553 this amount of cacao would have been worth no more than one fifth of a real, probably less. In the 1570's common labor received 300 grains of cacao per week, or between two and three reales. In 1578 carpenters working on the cathedral of Merida were paid one real a day. Thus one half a real per day may be regarded as a fair estimate of wages for unskilled labor. The value of the individual tribute assessment varied from twenty-three to perhaps thirty-six reales. At one half a real a day for current wages, the tribute assessment would represent forty-six to seventy-two days of labor, a truly astonishing figure!

The Tribute an Excessive Burden

The excessive burden of the tributes is indicated also if we try to arrive at some estimate of what the unit of assessment represented in terms of maize consumption. In 1606 the total value of the assessment for a married adult was thirty-one reales. Maize in that year was valued at four reales for about seventy-five pounds. The total assessment represented, therefore, the value of about 580 pounds of maize. Steggerda has found that at the present time the average consumption of maize per person is about 1.33 pounds per day, or for a family of five about 6.7 pounds. The 1606 assessment for the head of a family considered in terms of maize would, therefore, provide for the needs of a family of five for eighty-seven days. We can not be sure that the consumption of maize per person or per family was the same in 1606 as at present, but in view of the fact that maize has always been the most important article of diet, the variation would not have been great.

But the tribute formed only a part of the total burden of payments which the Indians had to make. Each married adult paid one real a year into a community fund to provide for the local pueblo government. There were gifts to the village priest or to the bishop for extraordinary services. A share in the expenses incident to the construction of churches and monastic foundations in the important towns was borne by the Indians, as well as one third of the cost of building the cathedral of Merida. Extra-legal demands, especially for food and shelter whenever the encomenderos and their retainers visited the pueblos, were common. And twice during the second half of the sixteenth century the Crown asked for loans or donations.

System of Forced Labor

When the Crown ordered the abolition of the labor phases of the encomienda system, it had to provide some substitute, as the colonists were dependent on the natives for house servants, unskilled laborers for various services, burden bearers and semi-skilled artisans for house building and public works. The Spaniards were free to employ all the labor they needed at the current rate of wages, but the supply of Indians willing to work, even for pay, was often inadequate. Consequently, the Crown found it necessary to authorize a system of forced labor by which quotas of workers were summoned periodically from the Indian pueblos to serve in the mines, on farms, on building operations or in workshops of various kinds. For this labor

they received wages at a fixed rate. This system of forced labor was generally applied in all parts of the Indies.

In Yucatan the demand was chiefly for house servants, building workers and porters. The employment of Indians as porters, or burden bearers, is the most interesting phase of the labor problem in Yucatan prior to 1600, and it illustrates the manner in which the humanitarian principles of legislation so often had to give way before the hard facts of administration.

Informed that the use of Indians as porters in various parts of the Indies had resulted in very serious abuses, the Crown issued orders strictly limiting this form of labor to areas where pack animals were lacking or could not be used—and even in such areas the Indians were not to be forced against their will to perform this kind of service. In Yucatan for twenty years after the conquest there were few roads or pack trails, and the supply of oxen, horses and mules was inadequate. Consequently the employment of Indian porters was universal. The most important demands for this kind of service came after harvest, when the maize that was paid as tribute or purchased for export had to be carried from the villages to Merida and the other Spanish towns. The wages for this form of labor were probably the lowest that were paid; the average load of maize was between fifty and seventy-five pounds; and a day's journey, according to the wage scale, was five leagues. Moreover, the Indians were given no choice in performing this service. Levies were called on order from the provincial governor, and caciques who refused to furnish the necessary number of porters were fined or imprisoned.

In 1563 the alcalde mayor served notice on the encomenderos that within one year they should purchase carts and animals for transportation of the tributes on the new roads being opened up, but this order was never executed. In the 1570's the defender of the Indians brought suit to force the encomenderos to give up the porter system, but after long litigation the matter was left to the discretion of the governor. The encomenderos made use of the obvious argument that the Indians had always been burden bearers, inasmuch as they had never had pack animals. The defender's plea was based (1) on the definite royal order that Indians should not be forced to perform this form of labor against their will, (2) on the alleged abuses of the system, especially the exhausting character of the work, and (3) the inadequate wages.

A Defender of the Indians

That the employment of Indian labor in Yucatan gave rise to numerous abuses and hardships is beyond question, but a large part of the documentary evidence is too circumstantial to be useful. But a brief review of the career of one of the defenders of the Indians who made a real effort to ameliorate labor conditions will indicate how difficult it was to mitigate the abuses which existed.

Francisco Palomino was appointed defender of the Indians in Yucatan in 1569 and served with brief interruptions until 1586. The energy and fearlessness with which he denounced flagrant cases of maltreatment of Indian laborers quickly earned him the enmity of both the governor and the encomenderos. The latter bought up his debts, hoping to bankrupt him, but he was saved by the intervention of Bishop Landa, who loaned him money with which to meet his obligations. He was removed from office by the governor, but was later reinstated by the Audiencia of Mexico. The governor then made public a memorial addressed to the Crown by Palomino in which he accused the encomenderos of various acts of violence and other abuses against the Indians. The encomenderos brought suit on the charge of slander, and Palomino was

forced to make a personal appeal to the Council of the Indies. The king sent him back to Yucatan to continue his labors, but a few years later he was once more removed from office by the governor, and he died while preparing to make one more journey to Spain to seek vindication. Palomino's long but futile campaign commands our sympathy. Unfortunately, he was a voice crying in the wilderness.

Effect of Christian Religion

The introduction of the Christian religion had just as profound effects on the traditional folk culture as the loss of political independence or the imposition of a system of tribute and labor which made the Maya "hewers of wood and drawers of water" for an alien race. It may have required an even greater degree of adjustment for the Maya to accept a new religious faith than to change political rulers.

The temple worship with its traditional ritual was the most highly formalized part of native religion, and the priestly class, as custodians of that knowledge which enabled them to perform the traditional ceremonies at proper intervals and to mediate between the people and the powers of the invisible world, exercised tremendous influence. But every individual, as he followed the daily round of life, planted his milpa, shared in the communal hunt, tended his bees and faced the crises of life, performed a series of acts that were religious or had implications of a religious character. The old tradition provided him with explanations for the phenomena of nature and the means for propitiating supernatural powers. It gave him standards of conduct and answers to the riddle of life.

And now, suddenly, he was informed that these traditional modes of life were wrong. A new God, new ceremonial practices, a new priesthood and new standards of conduct were offered to him —indeed forced upon him. That the new faith brought to the Maya definite benefits is too self-evident to require discussion. But it also had powerful repercussions on Maya life and folk achievement which we are likely to forget.

The Missionary Program

The missionary program had two phases—the positive and the negative. The positive phase included the teaching of a few essential elements of Christian faith and ceremonial; the negative consisted of measures to destroy the old cult, and, in so far as possible, the confidence of the Indians in the efficacy of the old ways.

The diocesan instructions of the first bishop, Fray Francisco de Toral, set forth the essential aims of the mission program in this early period. The Indians were to be baptized as rapidly as possible after receiving some instruction in the new faith. This instruction should emphasize such fundamental concepts as the belief in one God, the nature of the Trinity, the Incarnation and the Virgin Birth. A few prayers were to be taught, such as the Pater Noster and the Ave Maria, and these were to be followed by the Creed. Reverence for the Cross, respect for the clergy and punctual attendance at mass were stressed. Persons in danger of death were to be given general confession and called upon to renounce the devil and the idols by which he deceived men. Especial care was to be exercised in teaching the true character of the sacrament of marriage, and the degrees of carnal and spiritual relationship within which marriage was prohibited.

But even these few essentials involved a drastic change in the religious life of the natives, and the Spanish authorities, secular as well as ecclesiastical, realized that only by utmost vigilance could this minimum program succeed. The greatest threat to the new ways was the influence of the native priests and caciques and the continued practice of pagan

ritual. Consequently the negative phase of the missionary program was hardly less important than the positive. The celebration of Indian festivals at night was expressly forbidden, those performed during the day were carefully supervised and the wearing of old ceremonial costumes prohibited. Secret gatherings in the houses of caciques were not permitted, lest these meetings be made a means of perpetuating the knowledge of the old ways and the influence of the native leaders. The custom of employing a casamentero, or native marriage maker, was forbidden, as a means of ensuring the free character of Christian marriage. Body painting and the use of ear-plugs and nose ornaments were prohibited.

Enforcement of mission discipline required constant vigilance and effective disciplinary measures. The form often employed for serious offenses was corporal punishment. Persistent offenders were frequently banished from the pueblos, and from time to time the clergy, in conjunction with civil authority, exacted even more stringent punishment, especially for cases involving practice of the forms of idolatry.

Disciplinary Measures

The most celebrated case occurred in 1562. Informed that the Indians in the southern part of the province were performing idolatrous practices, Fray Diego de Landa, provincial of the Franciscans, with the consent and aid of the civil authorities, made a thorough investigation. Torture was used to obtain evidence, and several Indians confessed participation in human sacrifice. Later these same Indians repudiated their testimony, asserting that they had made false statements in order to escape the rigors of torture. Sentences of various kinds—fines, whipping, and in some cases a period of personal servitude varying from two to ten years—were imposed on the persons convicted of having taken part in idolatrous practices, but many of these sentences were later commuted to lighter forms of punishment by Bishop Toral. Thousands of idols were gathered and destroyed. In a few cases the bodies of deceased idolaters were exhumed and burned. Several Indians who had been denounced as participants in human sacrifices, of whom the most important was Lorenzo Cocom of Sotuta, committed suicide.

Perhaps the most interesting thing in the entire manuscript record of this famous incident is the clear indication that the persons against whom Landa and the alcalde mayor directed their attack were the caciques, the lesser chieftains and the native school masters. Ten chieftains of Mani were arrested and held in jail in Merida; seventeen from Sotuta; nine from Homun; thirteen each from Yaxcaba and Canchunup; as well as a long list from other pueblos. Altogether more than one hundred were thus publicly punished and humiliated. We should not be too critical of Landa and the alcalde mayor, especially if we realize that the evidence, obtained by torture or the threat of torture, it is true, and later repudiated, seemed to indicate the practice of human sacrifice. They were the agents of a virile, dominant culture which justly regarded such practices as an abomination.

But my point is not to argue the superior quality of European civilization and the Christian faith—they do not need an advocate—but to direct attention to the fact that by discrediting the former political and religious officers the authorities were attacking the intellectual leaders of the race. These men were the custodians of the complicated chronology and hieroglyphic writing which were such essential elements of the whole body of folk tradition. By holding them up to public humiliation, by a definite process of eliminating them from posi-

tions of influence and authority, by banishing them from their traditional haunts, by forcing them to practice their profession in secret, if at all, the civil and ecclesiastical authorities were striking a serious blow at some of the greatest achievements of the race.

As usually happens, however, the leaders of the conquering race, having demonstrated their superiority, turned antiquarians and preserved for us some knowledge of the traditional Maya learning. And of these antiquarians, Landa was the greatest!

Old Faith Not Wholly Destroyed

But despite the stern measures for the punishment of idolatry taken in 1562 and on other occasions later in the century, a considerable amount of folk religion survived as part of the everyday life of the people. What was lost was the temple ritual and the learning of the caciques and priests. The net result was to impose a veneer of Christian practice without wholly destroying the old faith.

The reasons for the failure completely to substitute the new faith for the old are numerous. During the first century after the conquest there was a lack of clergy. A single friar or secular priest sometimes administered a parish of several thousand. Moreover, the language problem was never surmounted. The village schools did not succeed in teaching Spanish to more than a small proportion of the Maya. Many of the clergy, it is true, learned the native language, but due to the fact that a large number of priests, especially in the Franciscan Order, were recruited in Spain, it may be doubted whether more than 60 per cent. of the clergy were proficient in Maya at any given time. Frequent petitions were made asking the Crown to order preference for clergy born in Yucatan in appointments to curacies, but during the first two centuries these petitions had little effect. Rivalry between the secular and regular clergy also reduced the effectiveness of the small and inadequately trained group available for the missions. Moreover, the lack of cooperation on the part of the civil authorities and the eager desire of officials and colonists alike to exploit Indian labor hindered the progress of the missionary program from the beginning. Finally, we must not forget that there was always a means of escape for the Indian who refused to accept the new régime. Hundreds escaped into the central part of Yucatan, where they could practice the old religion without interference from the Spanish clergy or civil authorities. And these settlements in the bush became in turn centers from which the folk religion could be "bootlegged" back into the conquered area.

The fate of the Maya was essentially the same as that of other aboriginal populations which have been brought into contact with a more advanced civilization. The influence of the intellectual leaders was gradually lessened. But everyday elements of culture, the language, the simple agricultural economy and a body of superstition that was preserved under the surface of a new cult remained, due largely to the inertia and powers of resistance of the masses.

SCIENTIFIC ADVANCE, MEDIEVALISM AND MODERN BUSINESS

By Dr. JOSEPH MAYER
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In the fourteenth century a series of disastrous occurrences gave tremendous impetus to forces which had long been accumulating in Europe and which eventually broke the vast power of the feudal hierarchy and the absolute authority of the Church. The depletion of the soil with extensive crop failures and great famine of 1315–16; the Black Death of 1348–49, which wrought incredible havoc and reduced the population 30 per cent. to 50 per cent.; the English Statutes of Labourers, beginning with 1349 and reenacted for a century and a half, which aimed to stem the growing tide of higher prices and wages; the abortive Peasant's Revolt of 1381; the Enclosures of England and the extensive turning of farm lands into sheep walks to supply a rapidly-growing foreign trade—these and similar occurrences marked the passing of serfdom and villeinage, the eclipse of small-town life (where craftsman rose from apprentice and journeyman to independent master), the ascent of a relatively few powerful merchant adventurers and industrial barons to positions of widespread economic control and the beginnings of the modern business system. In this transition feudal lord, emperor, king, pope and city merchant-industrialist struggled to retain or to gain supremacy.

Technological and Scientific Advance

As a result of these struggles for power, the fate of medieval Europe might well have been that of the ancient Greek city-states or of the Roman Empire had it not been for important technological and scientific developments which occurred in Europe during the same general period.

First, there was the thorough-going utilization by Europeans of three devices which in cruder form had been known for a long time, namely, the mariner's compass, gunpowder and the printing press. Improvements in these devices now opened up for Europe hitherto unheard-of opportunities for geographical discovery, colonization and further plunder; sealed the fate of the knight-errant with all his spectacular paraphernalia; and rendered the stored-up knowledge of the privileged few ultimately accessible to the humblest peasant. The effect of such advances upon the rise and spread of modern nationalism, imperialism, democracy and popular education, and the repercussions of these upon the economic structure and the extension of the modern business economy can hardly be overestimated.

By the fifteenth and sixteenth centuries, the first effects of these developments had already helped here and there to resolve the afore-mentioned struggles in favor of king, city and nation, and the scene of conflict was shifting to the international arena. The tremendous expansion of trade and industry following the Crusades of the earlier centuries and the later Portuguese and other voyages of discovery threw off medieval restrictions upon price movements and money-lending; the Protestant Reformation merely accelerated these developments; and the influx into Europe of plundered silver and gold from the New World, in addition to an increase of indigenous mining of precious metals, still further disrupted existing systems of prices. A veritable

commercial revolution was the result. Developments in the succeeding centuries followed in natural order: the rise of one monarchial nation after another to world power (Spain, Holland, France, Sweden, Russia, Prussia, England); a scramble for possessions overseas, in North America, India, Africa and elsewhere; the development in the United States and France of modern democracy. These political and economic changes were in the main the natural consequences of the technical advances mentioned.

Second, with the eighteenth century, scientific progress brought even more revolutionary changes in the economic realm, as an outgrowth, to begin with, of Newtonian physics and, later, as chemical discoveries added to man's increasing control over natural forces. The so-called industrial revolution, which followed the commercial revolution, was in essence a mechanical revolution. Machinery driven by artificial power, rapid transportation by railroad and steamship, world communications by ocean cable and electric telegraph, greatly increased use of structural materials and gigantic building with iron and steel, steam power followed swiftly by electric power and then by gasoline combustion and by the mass production of machines and appliances previously undreamed-of —these were the significant elements in the industrial advance. Nor were the political and social effects of the mechanical revolution any less important— the rise in living standards, the abolition of chattel slavery, the spread of popular education and the extension of democratic controls being among them. It was in the main scientific discovery and technological applications thereof which made the modern world a more promising dwelling-place for people in the mass than were even ancient Greece and Rome for a relatively few citizens at the height of the glory and splendor of those nations.

Further Developments of the Market and Price Systems: The Modern Business Economy

Further effects of revolutionary technological and scientific advance upon the institution of the market and price system have been mainly in the direction of a greater elaboration and complexity on the one hand and of a marked instability on the other, bearing in mind that the chief purpose of the institution continued to be served, namely, the yielding of feudal tribute, in so far as the medieval period lingered on, and the yielding of interest, dividends and profits, in so far as the modern business economy took more definite form.

In the various struggles between church and state, feudal lord and king, landed aristocracy and town merchant and industrialist, the chief economic issue continued to be one of what dominant class was to secure the greatest share of the medieval "spoils" or "surplus." In this conflict between dominant classes, the social and economic status of the people was little enhanced, and in some respects it continued to grow worse. The people still lacked political power; and the laws and judicial procedure covering property and status formulated by the feudal overlords—together with the ecclesiastical and dialectical sanctions supplied by the medieval Church—continued to offer innumerable stumbling-blocks to an improvement in general living conditions. Furthermore, until more recent times, the efforts of the people had to be concentrated upon the more immediate problem of securing greater personal and political freedom. Only as that primary problem came to be solved in some measure, could the people hope for any real success in attacking the problem of improving their economic status.

The "price revolution" of the sixteenth and seventeenth centuries, due

mainly to the influx of silver and gold from the New World (from Mexico, Peru and Brazil), produced marked effects upon estate holdings, colonization, export trade, ship-building and money lending. In the seventeenth century the London goldsmiths developed their operations as deposit bankers, lent money at interest, began to pay interest on deposits and finally issued "promises to pay" or goldsmiths' notes. The Bank of England was established in 1694.

At the same time, English wholesale and retail trade and foreign commerce became greatly augmented, the picturesque fair declined, large-scale business enterprises multiplied, insurance and hedging took on sizable proportions, the collapse of the Mississippi and South Sea undertakings in 1720 marked the beginnings of even greater speculative ventures, severe business crises followed with every passing decade during the second half of the century, and the London Stock Exchange came into being in 1773.

A new monied class now began to vie with industrialist and merchant for a share of the "surplus" through investment and banking operations, and the frenzied finance of modern times with its kaleidoscopic crop of millionaires and multi-millionaires was ushered in. Likewise, attention became focused here and there upon problems long neglected by the classical economist.

The commercial, trading and financial transformations just described paved the way for the establishment of the modern business economy, the most significant economic development of the period under review. The essential elements of any business system are a sufficient political security for the regular enforcement of trade contracts, some recognized medium of exchange, the accumulation of surplus stocks of goods and the conduct of enterprises for the primary purpose of profit making. Neither barter nor a household or manorial economy involves all these elements.

Various ancient states had developed business economies—maritime and merchandizing trade, money and banking facilities and profit-making ventures having been elaborated to a considerable degree. But business practices then, and on a reduced scale throughout the medieval period, were confined almost entirely to commerce and finance. Industry as such was primarily a household affair, and agriculture was carried on chiefly by slave or serf labor with non-business factors and processes predominating.

What distinguishes the modern business economy from earlier forms is its extension to industry and agriculture, particularly to the mass production of fabricated commodities with the use of highly developed machine technique, made possible by the scientific advances outlined.

If, toward the end of the eighteenth century, England led the way, as she did, in the extension of business practices to industry, it was because of the aforementioned wide expansion of her trade, the proficiency of her merchant-adventurers in the arts of finance and money-making, the development of her textile industry on a machine basis, ready access to the raw materials necessary for large-scale industrial use, and because the enclosures of her agricultural lands drove large numbers of dispossessed peasants to the cities, where they could be readily utilized as factory laborers. The relative political security of England and the liberality of her laws of contract were also important factors in this development.

On the Continent, conditions were not as favorable. The Napoleonic and other wars of conquest and the continuance of medieval restrictions held back industrialization and the expansion of business there. Furthermore, in France the

workers remained relatively secure in their medieval agricultural pursuits, in Germany and Italy the struggles between petty feudal lords and ecclesiastical powers continued to render difficult any unified national development, and other countries remained even more backward.

To colonial America, European settlers had brought the economic customs of the home countries, including old-world ideas of property, status and the market and price system. For a time frontier life in a new land caused a reversion to barter and economic activity for immediate use rather than for profit; but by the end of the nineteenth century, the frontier in the United States had virtually disappeared, the modern business economy had been quite generally established, and American industry and trade fashioned upon European precedents had assumed a place of world leadership. In agriculture, financial organization and investment control, however, America still lagged behind England.

Changes in Economic Thought and Policy

While vast scientific and technological changes were in process and as a result industrial and political units were growing enormously more complex and the modern business system was becoming more or less universal in scope, the world of economic thought and policy remained curiously stagnant, or, rather, the feudal structure of legalistic, judicial and ecclesiastical controls and their dialectical rationalization continued with little change so far as the main stream of economic thought and action was concerned. For the most part during the transition period, the process of rationalizing and apologizing for things-as-they-are went on unabated. The subtle medieval dialectic, with its apologetics for the *status quo*, could hardly be improved upon, and so it survived with merely a change in emphasis and direction as to what form of dominant tribute-taking was to be regarded as "proper" or "right."

Modern Mercantilism

With the triumph of monarchy and nationalism in the sixteenth, seventeenth and eighteenth centuries, a reawakened doctrine of mercantilism succeeded the doctrine of the "just price," to the rationalizing tenets of which it added little beyond the revival of certain Roman and other ancient trading dogmas. For the rest, the medieval tribute-rendering structure continued to be left unquestioned, except that now most of the "surplus" went to king, merchant and industrialist.

Though English, French and German definitions of renascent mercantilism differ somewhat in outlining its extent and significance, there is general agreement that it constituted part of the nationalistic policy of growing monarchies in bringing territorial unity out of feudalism and in enhancing the wealth and commercial power of a given state in competition with other states. Modern mercantilism sought primarily to make the rising nation as such powerful and prosperous, toward which end monarchical regulation of economic affairs was extended to the most humdrum of activities. In England, unity had been achieved and feudalism was already on the wane by the fourteenth century, but on the Continent, where disruptive feudal influences continued four to five centuries longer, various town monoplies and river, highway and other local tolls and exactions obstructed the free movement of trade and the extension of the business economy.

Besides resulting ultimately in the correction of such internal disharmonies and obstructions through drastic nationalistic decrees, the expansion of modern trade beyond state boundaries brought additional occasions for centralized governmental control. Special trading com-

panies were chartered under severe restrictions (as in Spain, Portugal and France) or under dearly-bought privileges (as in Holland and England). In England, where such restrictions were least in evidence, attempts were nevertheless made (as in the Bubble Act of 1719) to check the growth of the "company" in industrial organization. Crude ideas were also held and carried into effect, in connection with mercantilistic tenets, about the virtue of encouraging exports and hampering imports and about the alleged necessity of collecting a large national stock of precious monetary metals to assure the state's wealth and prosperity, ideas which Adam Smith later severely criticized together with the related conception that wealth can be measured primarily in terms of gold and silver. It can not, however, be said that even to-day we have advanced very far in clarifying these ideas. It seems, in fact, that we have recently taken a new fancy to some of them.

To return to the historical account: During the two or three centuries that modern mercantilism held sway, nations rose and fell in wealth and power. At the same time, merchant adventurers and industrial barons prospered increasingly; and as their wealth and power increased, so did their disregard of onerous mercantilistic restrictions. Also, in a growing number of instances, regimented mercantilistic restraints broke down of their own weight. And finally the physiocrats and Adam Smith cast general doubt upon the virtue of the doctrine itself, by launching the opposing doctrine of laissez-faire, which aimed to prove that nations could become even greater and more prosperous if mercantilism were abandoned and neither the state nor any other coercive body were allowed to interefere with what was being redefined as a "natural order" of economic harmonies, automatically regulated by the spontaneous actions of individuals in their own interest.

Laissez-Faire

The idea of laissez-faire is encountered fairly early among Italian economists, but it apparently first took firm hold in the eighteenth century in France among the merchants (as Gournay and Legendre) and among the physiocrats in their fight against mercantilistic restrictions. In England, Adam Smith promulgated it at the end of that century, and it became current there with John Stuart Mill in the middle of the nineteenth century.

Besides representing a protest against mercantilistic restrictions in general, laissez-faire was, at the beginning, also a protest against any taxation of industry by the state, both of which were natural enough protests at the time, since governmental restrictions and taxation alike continued to reflect efforts by king and feudal baron to maintain the medieval tribute-rendering mechanism intact. In the end, for one reason or another, laissez-faire swept the realms of theory and policy alike and, at least so far as the older form of modern mercantilism was concerned, occasioned the abandonment of that doctrine. The acceptance of laissez-faire as a national policy accelerated the spread of the modern business economy.

Theoretically, certain of the assumptions of laissez-faire are highly important, since they allegedly take into account the welfare of every citizen and not simply that of a powerful few. In the main, these assumptions are: (1) that every individual naturally and with thorough-going rationality pursues his own interests; (2) that he can best follow his bent if left to himself, unhampered by governmental restriction or private organization; (3) that in freely pursuing his own interests, each individual, whether employer or workman, will amass the maximum of wealth for himself; and (4) since national wealth is merely the sum of individual fortunes, that the nation's wealth and happiness

must under laissez-faire reach its maximum. As part of this doctrine, Adam Smith consistently argued against the chartering of joint stock companies, on the ground that, in such organized business concerns, collective management is substituted for individual enterprise. Laissez-faire was, therefore, among other things originally directed against tariffs, diversions of trade or of precious metals from the channels of their "natural flow," corporate business organization and monopolies of every variety.

Left out of account, however, by Adam Smith and his followers, were certain practical conditions and developments which in large part nullified their theoretical assumptions. These nullifying factors were in part: (1) the medieval tribute-rendering mechanism was still intact in its legal, judicial and practical aspects, sharply differentiating the hereditary property-holding rights and privileges of the few from the obligations and social submergence of the many, making it impossible for the common people to pursue their own interests unhampered and enabling the merchants and industrialists to continue to secure increasing advantages for themselves. (2) These feudal restrictions and traditions made it extremely simple for those who had money and property to gain more money and property, while rendering it difficult for others to secure even a foothold. (3) The assumption of a predominance of rationality in economic behavior was not in accord with the facts. (4) The supposition that a removal of mercantilistic restrictions would leave competition free, either as between the ruling classes and the masses or as between competing merchants and industrialists, was thus unwarranted, both because of the continued existence of the feudalistic mechanism of political and economic controls and because of the lack of any regulation to prevent merchants and industrialists from getting together and restricting competition in their own interests.

It did not take long for some of the shortcomings of laissez-faire to become manifest: Women and minors were treated scandalously in the factories, so that it had to be conceded that probably they did not know "their own interests"; factory conditions in general brought new industrial uncertainties to wage-earners until their lot became notoriously bad; monopolies developed rampant, despite the vaunted benefits alleged to flow from "free enterprise" in preserving competition. These difficulties brought new legislative restrictions, though of a somewhat different character from the older mercantilistic decrees.

But despite all this, the unreal assumptions of laissez-faire accorded so well with the aims of growing business and with the inchoate structure of economic thought previously devised by ecclesiastical and scholastic dialectic in connection with the doctrine of the "just price," that the practical difficulties (where recognized) came to be looked upon by business men and economists alike as mere aberrations or exceptions to the alleged beneficent "laws of nature." Nor did this further refinement of scholastic dialectic stop here. With the launching of Benthamism and utilitarianism, other powerful sanctions were added to the "natural order of economic harmonies." Now not only was man, in seeking his own interests, assumed to arrive at the maximum of material gain for himself and for society, but he was thus also assumed to arrive at the greatest possible pleasure for himself and for every one.

This reasoning was still largely on the side of productive effort (of the maximum supply of goods and pleasures), the technical economic arguments being directed to the idea of "cost." Then came William Stanley Jevons in England and the Austrians on the Continent, who emphasized "utility" to the consumer or the pleasures involved in demand. Henceforth, the classical justification via laissez-faire departed somewhat from the

Smith-Ricardian "cost" pattern for the new pattern of "utility," and the condemnation of governmental and monopolistic restrictions was shifted to the contention that these do not allow "free play" to consumer demand. The "natural-order of economic harmonies" was still retained, but in measuring "pleasure" and thus "value," the emphasis was changed from a "natural pursuit of one's own interest" to the prices consumers are "willing" or "offer" or are "prepared" to pay. Later came the final refinements of eclecticism, demand and supply being viewed as "two sides of the same shield" or as the "two blades of the price-setting shears," and the classical structure was complete. Bulwarked by Benthamism, marginalism, Austrianism and eclecticism, its general scheme of dialectic seemed to grow ever more plausible.

To what an extent this whole structure of classical and neo-classical economic thought, despite its surface plausibility, is interpenetrated with unwarranted assumption and false reasoning, the present writer has already had occasion to examine at length elsewhere. Here we are chiefly concerned to call to mind the major respects in which, with the abandonment of mercantilism, changing economic conditions and the establishment of modern business as an outgrowth of scientific advance did not conform to the "natural" course of events predicted by laissez-faire.

That the latter failed in its theorizing to take into account the conditioning rôle of medieval economic institutions has already been pointed out. Its further failures in prediction and in even surface consistency may in part be summarized as follows: (1) Despite the withdrawal of governmental assistance, corporate business organization underwent no natural decline; on the contrary, its spontaneous growth is one of the outstanding features of modern industry and business; hence the arguments of laissez-faire, based upon an inevitable victory for individual initiative and enterprise (if left to themselves), lose much of their significance. (2) Monopolies and combines have already been mentioned; they grew apace as corporate enterprise grew, until we witness the incongruous spectacle of governments issuing regulations to break them up, in the name of a laissez-faire one of whose primary protests was against state interference. (3) Similarly, we observe state after state passing factory acts to remove some of the "unhappy" conditions caused by a laissez-faire which insisted that happiness could be brought about by "natural laws" alone. (4) Again, as large-scale industrialism and business developed, salaried managers increasingly took over the actual conduct of business and the profit incentive shifted to the investment field, so that "individual enterprise" now centered for the most part upon the holding of stocks by absentee owners, which is quite contrary to what laissez-faire contemplated. (5) Free traders, in endeavoring to remain faithful to the precepts of laissez-faire, overlooked the fact that through formal and informal combines and monopolies large-scale producers have been increasingly able to exercise control over prices, while the unorganized consumer (who under "utility" economics should have complete freedom of choice) became less and less able to do anything but accept the price-ranges thus fixed. (6) Modern production has, in fact, become more and more regulated, both by governmental enactment and by internal controls. American anti-trust legislation and European cartels were already established before the world war; and since that time, not only has there been a further increase in industrial combination and restrictive legislation, but projects of national planning which deliberately link the state with economics have become wide-spread, whether we look to-day at Russia, Italy, Germany, Mexico or the United States.

In the realm of production, the tenets of laissez-faire seem nowhere to have worked out as predicted. (7) As for consumption, the disadvantageous competitive position of the unorganized consumer is now well known. In addition, after Austrianism rose to favor, it was soon pointed out that, where there is great inequality of income, price-offers as such can not in any comparable sense measure underlying "pleasures" or "utilities." A more equitable distribution of income and wealth would doubtless be conducive to greater general satisfaction, and this might well be brought about by state control and graduated income taxation, thus again contravening one of the basic "non-interference" tenets of laissez-faire in the interests of achieving another one of its tenets, the "maximum of satisfactions" or the "greatest happiness of the greatest number." (8) Also, while the economic power of the consumer has been increasingly weakened by large-scale corporate control and absentee stockholdings, his political power has become increasingly greater with the growth of democracy, under which he is progressively exercising direct economic interference in the interests of public welfare, again in contravention of the "natural harmonic" assumptions of laissez-faire. Here conscious democratic control is definitely replacing a let-alone governmental policy. (9) Finally, with respect to the alleged comprehensiveness of the "natural order of economic harmonies," a most important group of modern economic phenomena is left entirely out of account by laissez-faire economists, namely, that complex of events known as business cycles.

Considering by and large the developments in economic thought and policy just reviewed, we find that the chief beneficiaries of the change from older medieval doctrine to mercantilism and laissez-faire, brought on by modern scientific advance, were the merchants and the industrialists, although the monarchs and the lords continued to secure some of the tribute or surplus by virtue of persisting privileges, customs and land holdings, and although the people themselves were also supposed to benefit somewhat by the change to laissez-faire, especially by the lower prices which to some extent did result. In the main, laissez-faire appears simply to have added another sanction to the already-existing scholastic apologetics, the sanction of a supposed mechanically-operating natural law of "competition" or of "economic harmonies" under an allegedly "free enterprise," which, along with the assumptions of objective value, natural justice and a divine economic order, established by the earlier medieval rationalization of things-as-they-are, merely served to give further credence to the classical structure of thought. This rationalization, at the same time, continued to hold the wage-earners to their economic status, at least until they substituted direct political action for the wishful thinking of the upper classes. If the people benefited at all under the change to laissez-faire, it was chiefly because of scientific and technological advance coupled with new governmental enactments which they were able to secure in their own interests, hardly because of the let-alone laissez-faire policy in its practical workings, although theoretically it sounded promising enough, certainly much more "equitable" in its fundamental implications than the *status quo* doctrine of the "just price" or the imperialistic decrees of mercantilism. In its practical workings, the doctrine of laissez-faire seems chiefly to have enabled merchants and industrialists to consolidate their control over a tribute-rendering economic structure, in the wake of revolutionary changes in industry brought on by technological and scientific advance, as medievalism gave way to modern business.

THE PSYCHOLOGICAL APPROACH TO THE TRAFFIC PROBLEM

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THIRTY-SEVEN thousand persons were killed on the highways of the United States last year. In the fifteen years preceding 1935 more people were killed by automobiles than have been killed in all the wars of the Republic.

The problem is very definitely one belonging to psychology, because automobiles, properly handled, are fairly safe machines. In the various statistics that have been gathered about accidents, car failure is found to play a very minor rôle, and, if the accident is due to some mechanical defect in the vehicle, that defect is often contributed to by the indifference of the driver. For instance, most of the statistics concerning car failure as an accident cause indicate that the brakes were faulty or that a tire has blown out. Usually nowadays when a tire does blow out it is an old one which perhaps has been purchased second-hand after having been repaired so frequently that every point is a weak spot.

Whether a highway is good or bad does not determine whether there will be accidents upon it if we leave the driver's attitude and mentality out of the picture. People can drive over highways which are poorly paved, which are deeply rutted and which in other ways show lack of engineering improvements with the same relative safety that they can over a smooth road if the driver is cautious and has the proper psychological reactions.

The superficial aspects of the psychology of the driver have been known for years. In a study made by Dr. Simonin,[1] of the University of Strasbourg, in 1931, the bibliography lists references as far back as 1907, for in the bulletin of the Society of Ophthalmology of Paris of that year, Roche asked the question whether it was necessary to determine the safe minimum visual acuity of automobile drivers.

Since then much thought has been given by European observers to the medical and psychological problems arising from the operation of a motor car. In the first decade of the present century the authorities of Berlin, Germany, were demanding physical examinations, including a check of the eyes, and licenses were granted by them on condition that, among other things, the glasses a driver wore should correspond with those that the doctor had determined would result in adequate visual acuity. Naturally, in the years that followed, the ideas of scientific people concerning the physical and mental requirements on the part of drivers have changed. Builders of automobiles have developed their machines so that specific weaknesses on the part of an occasional crippled or otherwise handicapped driver can be properly compensated. The special motor cars which our President drives on his Warm Springs and Hyde Park farms are examples of this, and he is a classical example of the fact that a person with a physical handicap may be at least a reasonably good driver.

In 1928 a very far-seeing judge of the Recorder's Court in Detroit requested that a special study be made of one hundred traffic offenders who had been brought into that court for violations of the traffic ordinances and laws. This was probably the first forward step taken in America to look into the problem of why

[1] Dr. Camille Simonin, "The Automobile Homicide." Paris, 1931.

certain drivers have accidents, why some of them get arrested, and what part the driver's defects played in the serious traffic situation of to-day. A number of findings were tabulated and the report made by the Psychopathic Clinic at that time, written under the direction of Dr. Theophile Raphael, revealed important findings, one of which was a preponderance of feeblemindedness. This immediately gave rise to agitation that the feebleminded should be removed from the highways in spite of the fact that a number of other observers have found cases of extremely bright people, college professors, for instance, whose records on the highway and whose mechanical ability to manipulate a car were inferior to those individuals with borderline intelligence, making them more accident-prone.

Although complicated psychotechnical apparatus was installed in Europe for the measurement of aptitudes of locomotive engineers and bus drivers, the matter was not much stressed in this country until the National Research Council in 1927 granted money to Drs. Albert P. Weiss and Alvhh R. Lauer,[2] who at that time were at the Ohio State University, to make a study of the "Psychological Principles in Automotive Driving." Weiss and Lauer carefully studied what work had been done on the subject previously and came to the conclusion that some of the past work by Americans on the competence of street-car motormen might be of some significance in directing their research, and they made an extensive study of the psychological abilities manifested or not manifested by operators who were good or who were bad drivers. Contrary to the teaching of some laymen, they found that a very small group of drivers could be considered definitely "accident prone," that is, to have a large number of accidents, and they attempted to develop criteria for automobile drivers. Behind the establishment of such a criterion is always the question of what is "good" or "bad" driving. Nobody really seems to know to-day, even though it is seven years since Weiss and Lauer reported what they found. The fact that there is no central bureau for guiding and supervising psychological research has complicated the matter and given rise to various conflicting points of view.

At the present time there are three bureaus in the United States which are doing research work on the competence of drivers. Each has a different approach. Lauer has continued to work on the psychological requirements for safe driving, but recently he has stressed visual phenomena and, of course, this is only part of the answer to the problem. He, himself, will undoubtedly admit this.

DeSilva, at Harvard, in the Bureau for Street Traffic Research, has modified a number of Lauer's tests with the idea in mind of making some simple objective apparatus which can be manipulated by the layman. This approach, to my mind, is fraught with dangerous possibilities.

The third center for this work is the Recorder's Court Psychopathic Clinic (Traffic Unit), which has an entirely different point of view. Lauer and DeSilva are doing research work, qua research. The Recorder's Court Clinic is faced with the concrete problem of deciding whether or not a specific driver is safe to be behind the wheel of a car, and if not whether anything can be done to make him a safe driver or whether he is a hopeless case who must be removed from the highway. To study him, as Canty has reported,[3] he is given a physical examination to see if he has a physical defect, whether he is crippled or weak so he can not operate

[2] Albert P. Weiss and Alvhh R. Lauer, "The Psychological Principles of Automobile Driving." Ohio State University Studies. No. 11, 1930.

[3] Alan Canty, *Jour. Applied Psychology*, Vol. XX, No. 4, August, 1936; and *Public Safety Magazine*, March, 1937.

a lever properly, whether he has a visual defect that precludes his seeing objects standing still, cars coming toward him or the condition of the road ahead. He also is given a group of examinations which we might call psychophysical tests. These are in keeping with conventional psychology, *i.e.*, they are tests of reaction time and judgment ability of various kinds. The subject is also given a psychiatric examination or, perhaps better, a mental hygiene examination, for the object of this part of the personality investigation, even though it is carried out by a psychiatrist, is not primarily to find out if an individual is suffering from a mental disease, but to disclose less obvious but equally important deviations in his mental processes.

Since the situation is basically simple, it is surprising that the psychological basis of traffic deaths has by no means been solved. One reason rests in the peculiar scientific situation which exists among those doing research on the psychology of drivers. When a medical man does research he usually publishes his findings either in a note or a more extensive article in one of the professional journals, so that, if his colleagues are at all interested in applying his discovery to their work it requires little in the way of effort to obtain copies of the periodicals where his findings appear. The traffic specialists, in the first place, seem to prefer to give their material to newspaper correspondents, and even if they do publish it in scientific journals, their work is found in such obscure periodicals that they are not as a rule easily brought to hand. The frequent use of publications such as the *Journal of the American Optometric Association* and, in England, the *Personal Factor*, are examples of this. There is little interchange of thought between workers in this field, and natural professional rivalry seems to be accentuated in it. One can scarcely blame an honest research man for concealing his work until he has established the principles which he has set out to verify, but after he has obtained results in thousands of cases these results should appear in the literature, but only too often in motoring-psychology they do not.

The consistent use of the psychological examination of offenders now stagnates, and the reasons which I have given above are causes but they are not the only ones. Money which probably would be forthcoming for research in this field from various sources, such as the manufacturers of motor vehicles, highway commissioners and health officers, has been allocated only to a few persons. There is, perhaps, a reason for this, too, in that those who are engaged in the automobile industry have preferred to see as many cars sold as possible and, while they have made concessions to safety, the "personal" element offered a challenge to them, for it might cut down the volume of their sales. On the other hand, I have been told recently by far-seeing executives in automobile plants in this city that they feel that everything that can be done to make for safety will eventually have a sales value. Unfortunately, this point of view is not predominant in the whole industry.

Several hundred cases have now passed through the clinic, and our findings seem to be diametrically opposed in some respects to those which might have been predicted by the public as exemplified by members of "safety committees," police officers and other persons untrained in psychology.

For instance, the layman, when considering the subject of accidents, assumes that if the driver can stop in time he can avoid any kind of an accident. Newspapers and magazines are filled with articles showing how long it takes to stop a motor vehicle going at various speeds, on the assumption that if an individual

reaches an intersection at too rapid a pace, he can not stop in time to avoid a car which might appear from behind a blind corner or might suddenly emerge from some other obscure point. In order to stop in time it appears to the layman that there are only two facts involved: one is how quickly the driver can see a car coming and press on the brake, plus the length of time that it takes the brakes to stop his car after he has pressed on the pedal. To the superficial thinker that would seem to be the end of the problem: if a man's reaction time is slow and a car comes into view he can not press on the brake in time and he will hit the car.

To the psychologically-trained person the braking time with good brakes, of course, is a disregarded factor to be considered by the engineer, and the theory evolves that an individual should drive at a sufficiently slow speed so that the engineering problem of stopping the car will not be of much significance.

But engineers neglect an important problem, namely, how the individual is supposed to judge how fast he is going with regard to the braking power of his car. School children and others are taught by means of pictures and charts that it takes a certain number of feet for any car to stop and that motorists should drive slowly. Yet at the same time they are taught that they can drive faster on the open road than the street and are given no scientific clews as to the determination of what a proper speed is.

As one would more or less suspect from the discoveries of Lauer and DeSilva, reaction time is not of much importance. Usually it is tested by a relatively simple apparatus, a red light similar to the signal tower found in most cities is flashed in front of the subject taking the test. He steps on the brake, and the time transpiring between the flash of the light and the pressing of the lever is measured. It deviates very little unless the man is markedly diseased or paralyzed; even stupid and feebleminded individuals and those with an impoverished nervous system, but who have no acute nervous disease, deviate only a few tenths of a second. This usually means a matter of only twenty or thirty feet, unless the speed is excessive.

More important than the actual ability to respond quickly is the ability to spot the elements of an impending accident long before it is necessary to press on the brake sharply. If a man can stop his car in five hundred feet he should have an idea of what is going on in the road five hundred feet ahead so that if, for instance, he sees the wheels of a car pointing away from the curb, a man's arm projecting from the window, and smoke issuing from the exhaust, the mental pattern should give him a clew that the man is about to turn out from the curb and may come out without much consideration for the oncoming driver. In this way, being able to step on the brake quickly is of little value if the car comes out without warning.

We have found it interesting, however, to measure reaction time in order to look further for some disease. We often find it interesting to add a steering test if the time is lengthened. Those who have had the longest reaction time of the cases seen by the clinic have been people suffering from paresis due to syphilis, paralysis of certain muscles and stupidity almost at the imbecile level.

The person whose judgment of speed and of spatial relations is poor is perhaps more apt to get into trouble, because when he gets into a ticklish spot he may come too close to another object, but narrow areas through which a man has to drive are infrequent and if the man's attitude is such that he will be careful and watch what is happening, he is not

likely to have an accident. Few cases passing through the clinic show marked impairment of ability to judge speed and distance unless they show some other signs of organic illness.

The reason why most people are relatively safe drivers and do not collide with others is a comparatively simple one and has to do only with the fact that motor vehicles going in the same way are restricted to one part of the highway. If a fair rate of speed by all vehicles is maintained the likelihood of collision is small. An accident occurs only when this fact is neglected or when a man turns out of a stream of traffic to go on a part of the highway where it is predicted that cars going in this direction would not be.

The two characteristics of the driver that are most stressed by policemen and others who think that they have the answer to the traffic problem in the matter of examining candidates for licenses are vision and intelligence. In regard to the last, I believe that I have already indicated that intelligence in itself is not a serious factor in the commission of accidents. Naturally, the more stupid a man is, the more likely he is to make a poor judgment in case he gets into an extraordinary situation, but unless someone else complicates the problem, a man with a limited degree of intelligence can keep himself out of trouble by driving slowly and observing every law. The traffic laws are sufficiently simple so that a high-grade feebleminded man can remember them and react to them properly. This is perhaps the reason why we find that many feebleminded truck drivers do not get into trouble over a period of years.

The clinic knows of many such drivers and interprets their ability to drive safely over a period of years as being due to the fact that drivers get out of their way and trucks go so slowly it gives the truck driver time to make a decision and figure a situation out. This he would not be able to do in driving a pleasure car. Occasionally we find a man who has driven a truck for a long time without getting into trouble but who, when driving his own car, is affected by the speed of the car unfavorably because he is habituated to the slower speed of a truck.

In such a case, if the man is feebleminded, this is of importance. One particular example will illustrate this. The man was sent to the clinic because he had failed to stop for a red light and crashed into another car. This man was found to be feebleminded and had had three accidents after he had purchased a pleasure car for his own use. Previous to this time he had for some ten years been driving a street-sweeper without any untoward effect.

Because so many people with poor vision are found by the police, and the newspapers have made note of this fact, much emphasis has been placed upon tests of vision for the driver. In 1931 Simonin pointed out that even at that time there was a marked difference of opinion about the importance of physical defects. As investigations have progressed we have become more doubtful about where to draw the line about vision and a man's ability to drive. In 1931 there was a debate in European scientific circles about whether a one-eyed man should drive. The argument was that he could not see cars coming from behind or sharply from the side of the blind eye. On the face of it, this seemed to be a logical argument, but again safe driving would seem more to depend upon the prediction of impending accidents than upon the emergency reaction. In the clinic we have seen many cases of one-eyed drivers who have had no accidents. Some of them have supplemented the good eye by mirrors which permitted them to have a wider range of vision. Others were merely careful and turned

their heads sharply when crossing intersections.

Naturally on the basis of probability alone, more things could happen which might bring about an accident in such a case than in the case of an individual with normal vision in both eyes. Most intelligent and socially minded persons with but one eye can keep out of trouble. The same is true with individuals who have lost a limb, but have supplemented this lack of body-part by braces or artificial apparatus of some sort. The writer knows of one man who even had artificial arms on both sides who had never had an accident because he was careful. He drove only on country roads, at a slow rate of speed, compensating for his defect by being careful about his driving.

The usual visual tests which we give to school children who show eye weakness would have only a questionable place in tests for driving ability. For a person who can only read what he should see at sixty feet at twenty feet has poor vision from the standpoint of eye comfort, yet has vision sufficiently acute for adequate driving. We even know of a case, whose vision would be considered bad from a standard set up by eye specialists, who could only see at twenty feet what he should be able to see at one hundred feet. This was not of as great importance as the layman might think, for even though he could only see the letters and not make out their shape at twenty feet, a man with such bad vision can see a car almost one-half mile away on the open road. If he is following another car he can see details sufficiently at one hundred yards so that he can predict what the driver is going to do.

Sometimes there is defective ability to estimate the relative positions of distant objects. This is important but occurs seldom even in the accident-prone population. In such cases a lack of balance of the muscles of the eye is revealed, but the man still can drive. His proneness to accident increases remarkably when he has a defect of this sort, but he, too, can often compensate by careful driving and a proper attitude toward driving. He usually requires skilled ophthalmological help.

Color vision is another factor which receives a lot of emphasis from the lay traffic expert, because 4 per cent. of the population are supposed to be blind to red and green. In other words, he supposedly can not distinguish between red and green traffic lights. It is true that 4 per cent. of the population are color blind according to standards used by researchers, but these individuals usually prove their ability to "spot" the colors in the traffic lights. Only in one case out of several hundred did we find a color-blind man who was blind to the traffic lights, and he was feebleminded, which was perhaps the more important factor in his case.

Range of vision is stressed. There are supposedly a number of people driving who had "gun barrel" vision, that is, they could only see a small area in front and were blind at the sides. From a number of tests on the general population and from our observations in the clinic we would predict that one in two or three thousand would have a diminution in vision of that sort. Visual defects of this type are measured by an apparatus called a perimeter, a semicircular device with the eye at the center of the circle. A disk is moved from the outside to the center. While the eye is fixed on the center of the circumference, the individual tells when the disk comes into view from the side. This shows that he has a blind spot, which is most important in causing accidents, but its great significance seems to be that it indicates the need for a physical examination to see whether it is due to neurosis, to syphilitic damage, diabetes, Bright's disease or brain tumor.

The layman becomes very disturbed

over poor hearing on the part of a driver. As a matter of fact the police department in Detroit ordered that no deaf man be granted a license by the License Bureau, yet all of us might just as well be deaf about 40 per cent. of the time. In the winter time we drive with our windows closed and our motor vibrates so we are fortunate if we can hear a horn but a few feet away.

The crux of the matter seems to lie in the measurement of the subject's attitude toward law enforcement and toward the rights of others. If he is anxious to do well, he will keep out of trouble as far as possible; and, if he is not easily excitable, he should be able to compensate for his visual defects and body structure.

I might summarize the results of our findings in the clinic and of our research into the literature by saying that mechanical tests of a driver's ability are of value but are sadly misunderstood, that a complete understanding of the nature and of the make-up of the individual, his attitude as well as his physical structure, are probably of much more value in enabling us to predict accident-proneness, as his ability to react promptly and to make good judgments, measured by machines.

Unfortunately, attitude and emotional stability are the most difficult things to test. Our best answer to the problem is by means of a polygraphic study of reaction time tests to see whether, as the situation of driving and stopping becomes complicated, the man becomes excited, as indicated by changes in his blood pressure and breathing. In testing his attitude, too, an association-test of words, such as police, law, *et al.*, can be given and his reaction to them can be recorded. If his history shows that he has been unstable in various situations or the psychiatric examination shows that he can be steered to anti-social behavior because of a suggestible make-up, these facts are of significance.

The deciding factor as to whether such tests are of value lies not so much in the test itself as in the ability, training and experience of the men who give the tests. The time has not yet come when these tests can be sufficiently standardized so that they can be placed in the hands of the police department or licensing board. In the hands of a layman who can not interpret what blood pressure recording means, these test results would be dangerous, as for example, a man who was not disturbed in traffic, but was disturbed by the laboratory situation, might be unfairly ruled off the road. Hundreds who are not disturbed in the laboratory, but are really unstable, might be permitted to drive.

It has been the policy of the clinic to recommend correction of all deviations found, but if they are extremely serious or complicated by a faulty attitude, the patient has been temporarily or, in some cases, permanently removed from the highways.

A serious criticism is made by police officers, newspaper men and others when psychological techniques are shown to them, namely, that these techniques do not reproduce the actual driving situation. When the man is taking the steering test in the clinic his mind is not reacting the same as it would if he were actually steering a car in traffic. They claim that when the red light flashes before him in the clinic he does not need to react as rapidly, perhaps, as he would on the streets. The proof of the pudding is in the eating thereof, namely, we can say that many can pass road tests who can not pass a laboratory test, that success on an actual test of driving is much more likely to occur in an inferior individual, so that weaknesses are not revealed, but when passing the man through a clinic examination these are shown up. On the street he has the benefit of habit and training which conceal how he would act

in danger, while in the clinic we can test for innate reactions by medical and psychological methods. Probably the only psychological test that would appeal to the layman would be a road test, but the only road test that would be as accurate as a psychological investigation would be one with completely standardized methods, including collisions and other emergency situations. The road test as given by police officers usually does not involve the creation of anything that simulates a situation in which the man would be likely to let himself get into an accident.

I have tried to show the reader the difficult situation that confronts any one who is trying to deal with the psychological aspect of motoring, and I hope this will serve as a warning against jumping at conclusions about what factor does or does not cause an accident. The average traffic "expert" takes a superficial attitude. He talks glibly about color blindness, reaction time and other tests of that sort which, I think I have indicated, are at best only suggestive of some deeply complicated condition if they are found to be abnormal. I would not for the world want the reader to believe that the clinic has found mechanical tests of one's driving ability worthless. This is by no means true, but the clinic does frown on using apparatus to the exclusion of other scientific techniques. The total personality should be considered in the same way that it is in a mental hygiene clinic. No modern child guidance clinic would make a judgment on the intelligence test alone. As a matter of fact one of the efforts being made by such clinics is to lessen the emphasis placed upon so-called I.Q. tests and upon physical deviations, although at the same time admitting that these tests are important. Public officials, newspaper men and others who stir up hysteria about the number of increasing traffic accidents are prone to demand that science go the whole hog or nothing. They are unwilling to wait for carefully standardized and scientific techniques. From our own experience we believe the clinic has at hand a number of these and our experience in dealing with drivers bears us out. A few drivers whose licenses we have suggested revoking and who have been permitted to continue to drive have become involved in trouble within six months' period of time, not always serious, to be sure, but yet, according to the laws of chance, one of these minor accidents might well have resulted in a death.

DOSTOEVSKY'S MASTER-STUDY OF THE "PROTEST"

By Dr. PAUL C. SQUIRES
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"SIBERIA. On the banks of a broad solitary river stands a town, one of the administrative centers of Russia; in the town there is a fortress, in the fortress there is a prison. In the prison the second-class convict Rodion Raskolnikov has been confined for nine months."

Thus opens the epilogue to "Crime and Punishment," that bizarre, powerful work upon whose pages Fyodor Dostoevsky ruthlessly lays bare the soul of a young murderer. As the exiled novelist wrote his brother Michael from Semipalatinsk in 1858, "such a figure frequently emerges in actual life." It is certain that no one before or since has rivalled this profound exploration into the dark abysses of the wrongdoer's mind.

Led out into the Semjonovsky Square of St. Petersburg with the other members of the Petrachevsky conspiracy, the young Dostoevsky was bound to a stake. He expected to live but another minute, when the barbarous mock sentence was commuted to imprisonment. The four years he served at Omsk in Siberia furnished him the psychological laboratory from which emerged the tormented beings of the "House of the Dead" and the dreadful realism of Raskolnikov's clinical portrait.

Just who was Raskolnikov? What lines of hostile forces had converged upon this youth of twenty-three, driving him to murder, then onward to confession and inevitable punishment? Was there a gradual regeneration and resurrection in waiting for him? If so, through what agency?

The whole world knows the story, which has recently been filmed. Yet its lessons are subtle and inexhaustible; the implications thereof steadily grow and multiply with the passing of time. The interpretation given by Dostoevsky anticipates precisely that of contemporary thought. Summed up in one word, the master key to the criminal act is the psychology of "protest."

Why did the young student kill the pawnbroker hag? For the three thousand roubles he expected to find, whereby he might complete his law training and obtain a post to support his widowed mother and sister? This is what he claimed at the trial. As to his confession, he attributed it to heartfelt repentance; he even tried to exaggerate his guilt. But—"all this was almost coarse."

Planning the act, Raskolnikov soliloquizes: "It would be interesting to know what it is men are most afraid of. Taking a new step, uttering a new word is what they fear most." Then: "Am I capable of that? Is that serious? It is not serious at all. It's simply a fantasy to amuse myself; a plaything! Yes, maybe it is a plaything."

So, he can scarcely bring himself to believe in the gross reality with which his criminal imagery is charged. Especially at the instant when the axe crashes into the skull of his victim, everything remains chimerical—as if he were a mere bystander at the hideous scene.

Razumihin remarked that the guilty man can be tracked down by the psychological facts alone. Raskolnikov, suffer-

ing from acute consciousness of economic impotency, had developed the Napoleonic or Jehovah complex wherewith to combat the agonizing feelings of inferiority. During several years there had become increasingly evident in his case a loss of contact with people. He viewed society through the big end of the telescope, and society had shrunk to nothingness.

Withdrawing completely into his psychic carapace, practical ethical action was replaced by abstract contemplation. Said he, "I am thinking." Like Kipling's Bimi the ape, there was "too much Ego in his cosmos."

Then it was that this immature mind, at war with itself, wrote the fatal article advertising its social philosophy; not original, to be sure, but nevertheless giving testimony which would eventually be turned against the writer thereof with devastating effect.

Men, says Raskolnikov, are divided into "ordinary" and "extraordinary." The rule of life for the herd is submission. To the Chosen, however, any crime or transgression of the moral law is permissible.

Napoleon is the captain of the supermen who are strong enough to commit crime. Success is its own justification. Those who with magnificent daring "step across the line" have achieved the supreme goal: the conquest of fear.

Narcissus, son of the river-god Cephisus, fell in love with his own reflection in the water. He alone existed. The narcissistic essence of Raskolnikov's personality is powerfully portrayed in the dream about the brutal killing of the horse, where Mikola (the dreamer himself) shouts, brandishing the bar, "My property!"

His vocabulary had become narrowed down to "I," "my" and "mine." We are reminded of Kurtz in Conrad's "Heart of Darkness," who was forever preoccupied with "'my ivory, my station, my river, my'—everything belonged to him."

A frustrated, inhibited being, inordinately vain and sensitive as a mimosa, Rodion longed for nothing so much as independence. The will to dare expanded into a dangerous fixed idea. He will not confess to inadequacy. One must excel in *something*. If, thinks the unhappy boy, the "perfect crime" beckons as the only hope for bursting the shackles of fear, why, so be it. The great men of history have never been squeamish in the use of violence.

Besides, the pawnbroker harpy has no right to live. Like a vampire, she is sucking the blood of her helpless customers. What is she but a "louse," a "black beetle"? The student (really a projection of Raskolnikov) says to the officer at the inn: "Kill her, take her money and with the help of it devote oneself to the service of humanity and the good of all. What do you think, would not one tiny crime be wiped out by thousands of good deeds? For one life thousands would be saved from corruption and decay. One death, and a hundred lives in exchange—it's simple arithmetic."

This is pure rationalization, however, a flimsy bulwark thrown up to protect the sense of self-esteem. The primal motive comes to utterance under tremendous emotional stress in his full confession to the unfortunate Sonia: "I . . . I wanted to have the daring . . . and I killed her. I only wanted to have the daring. That was the whole cause of it."

Raskolnikov's crime represents his protest against a maddening realization of inadequacy. The act was carried out under the influence of a compulsive and virtually somnambulistic state, with the satisfaction of a psychological—rather than an economic—need as the true objective.

Moreover, rage against himself was insidiously transferred to hatred of his prospective victim; she conveniently crystallized for him in her repellant and avaricious person an unappreciative society. The eternal paradox of Roskolnikov's kind, expressed in Sonia's outburst, "How could you give away your last farthing and yet rob and murder!", now ceases to puzzle us.

In upbraiding Sonia for having destroyed her soul for nothing, Rodion is accusing himself. When imprisoned, wounded pride made him ill: his only sin was to allow his *legal* guilt to be revealed. Of pains of conscience he felt none.

Sonia tells him to go out to the crossroads and there bow down, saying to all men: "I am a murderer." He prostrates himself in the square. A drunken workman jibes: "He's going to Jerusalem, brothers, and saying good-bye to his children and his country. He's bowing down to all the world and kissing the great city of St. Petersburg and its pavement."

"Into the Future lead many paths," wrote Nietzsche. What accident of nature and special circumstances make one man a builder of the social order, another a criminal? Out of what differences in ferment do a Beethoven and a Marquis de Sade arise? Raskolnikov, kneeling in the square of St. Petersburg, personifies that legion of weaklings who project their self-hatred upon society.

Poe concludes his "Man of the Crowd" in this wise: "It will be in vain to follow; for I shall learn no more of him, nor of his deeds. The worst heart of the world is a grosser book than the Hortulis Animae, and perhaps it is but one of the great mercies of God that 'es lässt sich nicht lesen.'"

Just a quarter of a century after the American indited these memorable lines, another tragic figure in distant Siberia, from out the gloom of the prison house, unlocked the Book of the Seven Seals in the protest of Rodion Raskolnikov, whose crime was the manifestation and symbol of psychic impotence.

TYPES OF FOREST CARPETS

By Dr. ARTHUR PAUL JACOT
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NATURE has furnished her woodlands with as great a variety of carpets as may be found in a well-appointed home. Entering the woods we are delighted by such forest floor accessories as a cover of Dutchman's breeches, a mat of dwarf cornel, a runner of hay-scented ferns, a haze of woodland grasses sprinkled with pink moccasin flowers under a copse of lady birches along a sandy ridge, beds of autumn asters. In the swamps are spread a layer of lush cabbages studded by the handsome hellebore, runners of sarsaparilla or ginseng along a flood plain, a fringe of cardinal flowers or jewel weed along a brook.

Beneath this variety of herbaceous covers are mats of soft, deep, hair-cap moss cushions of dense grey-green moss, doilies of procumbent moss spreading over old logs and partly buried stones. Open places expose spongy rugs of reindeer lichens, and on old wood, stumps and boulders a great assortment of lacy, foliose lichens. Then all between is veritable diversity in the layer of leaf litter. The fragrant and springy pine litter, and the dark aisles of the hemlock gorge, with their dense carpet of minute leaves, have been enjoyed by most of us. One treads the northern woods on a mattress of spruce and balsam needles. The broad-leaf cover ripples over the hills in ever changing warp and woof, studded by brilliant little flowers that move about the surface, like the blue-tailed skink, the golden-tailed rove beetle (*Ontholestes*), the Calosoma beetle, with its emeralds and rubies set in black lacquer, a woodland butterfly fanning in a sunlit patch, or the minute vermilion Trombidium mites, the blue saddled springtail and a host of others.

CARPET STRUCTURE

The ordinary carpet of deciduous leaves is not a haphazard agglomeration of leaves but has as definite a structure as that of the fireside rug. After removing the few large dry leaves of the surface which form a Litter layer, one finds a more compact zone or layer of leaves which have a tendency to stick to each other by reason of the water-film held between them. These leaves are soft and flaccid, due chiefly to the action of fungi which have partly reduced their tissues. Fungus action precedes other reducing activities, and it can begin as soon as the leaves have enough cover to maintain a little moisture. Leaves further down in this layer are not only matted together but have the edges variously scalloped and the surface (epidermis) more or less removed in irregular patches, while some are skeletonized, that is, the soft tissue is entirely gone, leaving only the veins as an intricate, lacy network. Although reduction is caused by these various agencies, fungus is the most important and the most conspicuous, wherefore this layer may be known as the *F*ungus or F-layer.

Leaves from the south slopes of the hills of the southern Appalachian mountains show chiefly one type of fungus which forms its fruiting bodies in the spongy layer on the inner face of the lower epidermis. These bodies are globular and black. The process of decay is most easily studied by taking a leaf which shows white blotches in the general brown color of the leaf. If such a leaf, preferably oak, still wet from the woods, is placed top side up under a dissecting microscope with a magnification of forty, the upper epidermis can be pushed or rolled back by starting it at

the fork of two veins with a fine needle. (Fine needles can be made by mounting an entomological minuten-nadeln on a handle by means of sealing wax.) This will expose the palisade tissue, or what is left of it, each batch within its vein islet. These islets are inhabited by certain nematode worms. Some leaves are without them, others have them thinly scattered, while some leaves harbor many. Do they feed on the fungal spores or on the fungal hyphae or on the leaf tissue or on bacteria? Who knows? Other stouter nematodes may be found on the surface of the leaves, where wet.

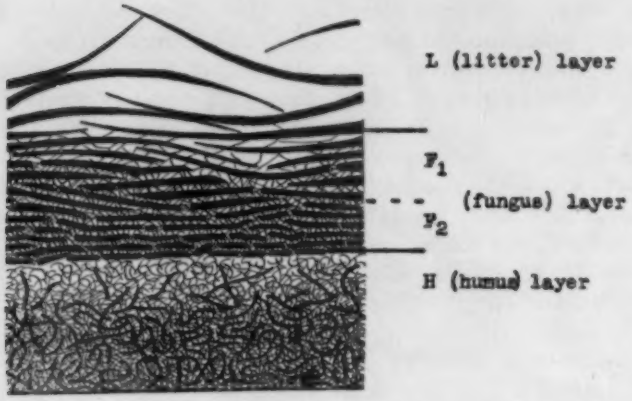
The under sides of dead leaves are quite "dirty." They often bear strands of fungi which hold down feces, both large and small, pieces of cast skins of insects or other arthropods and other minute organic fragments. As such a leaf dries, the photosynthetic tissue contracts and pulls away from the veinlets, thereby skeletonizing the leaf. Another type of reduction is engendered by various chewing arthropods. For instance, leaves may be found in which the lower epidermis has been removed over varying extents. Other leaves may have the lower epidermis, the spongy parenchyma and the palisade tissue removed, leaving the upper epidermis intact. More rarely, certain animals chew holes completely through the leaf. Some millipedes browse about the edges of the leaves. Earthworms, shoots of seedlings or young sprouts push through several leaves together.

Some leaves curl a great deal on drying. Animals take advantage of these and use them as shelters which are consequently found loaded with feces and debris. It is always the upper surface which is rolled in because it is smooth, often glossy and easily sheds water, hence becoming dry more rapidly than the lower surface, which is rough, irregular, ribbed, often with clusters of hairs in the forks of the veins.

Thus, the dead leaves may be reduced (1) by fungal digestion and bacterial digestion, (2) skeletonization (by drying or by animal ingestion) and (3) by fragmentation, chiefly by animals.

Moist leaves of the lower *F*ungus layer harbor a host of animals: fungus eaters, feces eaters, animal eaters, leaf eaters, parasites and transients, for here is plenty of moisture, plenty of shelter and plenty of food. White animals are the most conspicuous, especially the predaceous mites, which go dashing about, and the springtails, which hop about like fleas. Less lively are the immature stages of various saprophytic mites, like those of Ceratoppia, recognizable by two, long, divaricating white bristles on the posterior end of its oval body. They transform or molt on the leaf surface. There are also the young of Eremobelba, grayish with stout white bristles. Eggs —beautifully sculptured, opalescent, knobbed, ribbed, pebbled, chalky, scaly, kinds innumerable, are to be met. But even more numerous and much less conspicuous are the many brown, leaf-colored mites. The larger species occur to the extent of several per leaf, while no one has yet determined the number of minute ones per unit of leaf surface. Why should one? The numbers vary enormously according to the type of carpet and to the degree of moisture. Occasionally, the investigator is startled by having a millipede, centipede, sow-bug, beetle, roach or other animal that recalls dragons and hippos, by contrast with the minute forms, scurry across the leaf or his fingers.

Naturally, such hosts of animal life scatter their excrement about. Strange to relate, most of this animal spoor remains attached to the lower surface of the leaves, and soon becomes webbed down by fungal hyphae. Millipedes are the greatest contributors to the granules found plastered to the leaves—almost always to the surface facing the earth



DIAGRAMMATIC CROSS-SECTION OF DUFF CARPET

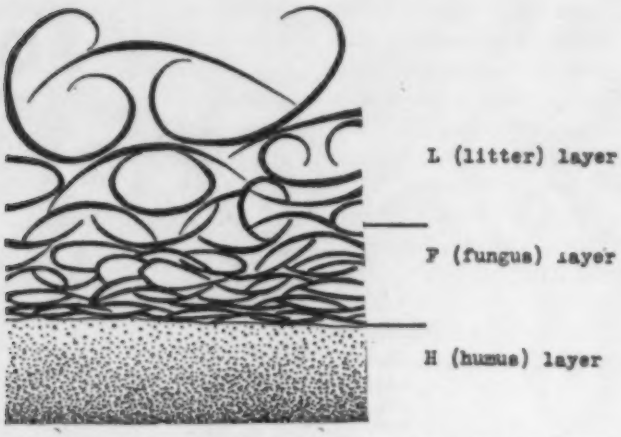
THE VARIOUS PARTS NOT DRAWN TO SCALE, FAECES OMITTED, LEAF FRAGMENTS SOMEWHAT SEPARATED.

(for leaves have a tendency to turn either side up in falling). The animals have the habit, perhaps sagacity, to push their feces into the forks of the larger leaf veins, or at least against the veins. This may have the indirect effect of hastening vein decay and reduction by such concentration of bacterial and fungal action. Howbeit, the open spaces are left more free for feasting. There are two kinds of millipede excreta. The feces are solid, smooth and dark green. Much more common is what resembles sawdust so agglutinated as to form ribbons or bars. This seems to be regurgitated pellets of partly digested leaves. In the mountains of North Carolina the red-backed millipede (*Polydesmus serratus*) is active all winter long when not frozen, chewing up the leaves. Any warm afternoon after a frosty morning adults will be found sunning themselves on the upper leaves of the *L*itter layer.

By this time the ardent investigator of this sordid life, where all things are something to some one, will have noticed that many of the leaf fragments are more or less "sewn" together by the minute white threads of fungi. It is the fungi, growing through and through and all about these discarded fragments, which bind this organic pabulum together like the woof in the warp. Hence fungi not only digest but amalgamate fragments by the binding action of the hyphae. Each leaf or leaf fragment is a warp thread, while the hyphae are the woof. It is right here that the different types of carpet originate. Some have more or denser woof and some more warp. Let us consider first the carpet in which the woof is more densely developed. Such carpets are known as duff, while those with less fungal hyphae are called mull.

The Duff Carpet

The duff type of carpet is characterized by a third layer, which we call the H (humus) layer. This layer consists principally of completely disintegrated amorphous organic material. It does not include fragments of leaves. It does contain a large quantity of granular material or feces which originated in part in the *F*ungus layer, in part from the overhanging vegetation, in part from earthworms and other soil-inhabiting animals which cast their intestinal wastes above the mineral soil, and in very local part by the feces of animals roving about the forest floor or in the vegetation overhead.



DIAGRAMMATIC CROSS-SECTION OF MULL CARPET

THE VARIOUS PARTS NOT DRAWN TO SCALE, HYPHAE, FAECES AND GRANULES OMITTED, THE BLACK GRANULES IN THE H-LAYER REPRESENT MINERAL PARTICLES, THE WHITE REPRESENTING THE HUMUS.

Normally, the *H*umus layer should form part of the mineral soil, as is the case in the mull carpet, but in the duff carpet it is retained above the mineral soil as a definite layer below the *F*ungus layer. This development was first described by Muller working in Danish forests. He found it wherever the roots of the beech trees, which form extensive forests in middle Europe, spread themselves above the mineral soil. A similar condition obtains in the Appalachians under mountain laurel and rhododendron. These tall ericaceous shrubs form a dense webbing of rootlets above the mineral soil and just under the leaf carpet. As ericaceous plants secrete considerable root acid these rootlets build up a medium which is particularly invidious to earthworms but salubrious to a brown fungus known as Cladosporium. Hence, at once, the most widely known soil mixers are eliminated, and the toughest brown fungi are encouraged. A characteristic of Cladosporium is that its hyphal walls include a great deal of chitin, a hard, brownish, almost indestructible material which makes up a large part of the body wall of beetles. Cladosporium now develops luxuriantly, twining about the network of rootlets of the Ericaceae, filling all the interstices with a much finer meshwork than the rootlets. The combination of a dual system of meshes forms so complete and fine a screen that the particles of humus from the *F*ungus layer are held, clog up the sieve spaces and do not get to the mineral soil. Consequently, the mineral soil lies hard and yellow, like a golden oak parquet floor, under the carpet, which is rendered so tough by the root and Cladosporium meshing that it is difficult to push one's fingers through it and rip it up. Magnificent carpet! Yes, most durable. But that is not what the foresters desire.

The Mull Carpet

In strong contrast is the mull carpet. This may be found under any cover of herbaceous plants, especially annuals, whether spring or autumn (Compositae). The *F*ungus layer is so thin and loosely woven that one has difficulty in finding leaves matted together. So loose is the weaving that the woof is barely perceptible. No brown Cladosporium fungus develops its meshwork. Under this loose and openwork *F*ungus layer lies that fine

black granular material which is so much sought after for garden-flower culture. You can run your fingers deep into it and find no yellow mineral soil. It is really the same humus material (feces) that is retained in the *H*umus layer of the duff, but here there is no meshwork of rootlets or of Cladosporium fungus to retain it. Moreover, there are many earthworms of various sizes. Microscopic examination of a sample taken from the black *H*umus layer reveals particles of mineral matter, for the earthworms, ants and other soil mixers have brought mineral soil up into the H-layer, where it has become mixed with the humus, which is nothing more than partly digested vegetation. These mineral granules are not larger than can be ingested by the earthworms, or carried by ants and other soil movers (where the soil has been undisturbed by mammals or the forces of inanimated nature). In mull soil then, the *H*umus layer is so much mixed with the mineral soil that its lower boundary is indefinite, gradually changing from black to the yellow or red of the underlying mineral soil.

Of particular importance to the forester is the fact that in mull soil the tree roots are brought in direct contact with the feces, while in duff soils they are not. These two types of carpet are therefore indicative of two extreme soil conditions: one hard and foodless, the other infiltrated with finely divided animal excrement; one caused by tall ericaceous shrubs, the other brought about by ephemeral herbaceous plants; one "acid," the other less acid.

Extracting the minute animals of these two carpets reveals an astonishing contrast. Not only are the species quite different, but there is a great diversity in numbers and size. Although the total number of species may be the same in each, in the mull carpet the species are large with relatively few individuals, while the duff carpet harbors minute species, each represented by hundreds of individuals. It is therefore evident that the penetrability of the animals of duff is greater—testifying to the closer mesh of the duff. In the open, loose weave of mull, the large species find no obstruction to their movements. The total bulk of animal life of each may therefore be the same.

The White Pine Carpet

Another type of carpet will be found in evergreen needlewoods. Let us take the white pine carpet as an example, say an old-field plantation. The removal of the topmost leaf-clusters reveals a grayish to blackish layer of needles. Such discolored needles already have the five leaves of the bundle matted together by fungal hyphae and "sucked out" so that their walls are collapsed instead of plump. Cutting them in half one finds the spongy parenchyma gone, and only the central stele left. Below these emaciated leaves, but still in the F-layer, the leaf bundles are fragmented and various bundle fragments are matted together by the hyphae, forming a fairly dense and fibrous tissue. The upper and lower halves of the F-layer, therefore, have the same characteristics as the duff carpet, but that layer lies directly on the mineral soil, which is covered by a sprinkling of fine, blackish granules. Here, although reduction is complete, the soil does not seem to receive much benefit. No real H-layer, as found in mull soil, is developed. Herbaceous plants are few and widely scattered. Earthworms are uncommon and small. One must conclude that the white pine carpet is not conducive to good soil fertility. Can it be changed to bring about more mixture between carpet and soil? Here resides the secret of good forest soil and good forest culture. There must be annuals, and there must be root eaters and soil mixers.

Organic Granules

If the leaf carpet of an old-field stand is raised to disclose the underlying mineral soil, the soil surface will be found to be sprinkled with granules of various caliber. But most conspicuous, when present, is a disk two to three inches in diameter made up of granules of apparently uniform size. The center of these lacy doilies is an earthworm burrow, and the granules are the castings of the worm. They vary in hue, according to the color of the mineral soil from which they are largely derived, and average a millimeter in diameter, are slightly longer and have rounded ends. Usually the sides are embellished by concentric or conchoidal black streaks, which are quite prominent when moist. Although the castings of the large meadow and lawn earthworm (*Lumbricus terrestris*) are usually voided to form a nodular clump, the castings of the smaller, woodland worms are seldom found amalgamated, but are strewn over the soil surface or even on the lower, well-decayed leaves. Granules which are deep greenish-black to black are the feces of arthropods. Sometimes the granules will be more or less linked to each other by fungal hyphae to form clots or webs. With time and under certain conditions, granular material accumulates to form a definite *overlayer* of increasing depth. An overlayer of granules two or three inches in depth may lie over the hard mineral soil of an old-field as an entirely distinct unit. As the soil animals work the mineral soil, this sharp distinction becomes more and more obliterated and in time the overlayer becomes the mull horizon of mull soil.

Other types of granular material are also present. Some of them are slender, rodlike and rough. I have seen such under pines, made up of fragments of poorly digested pine needles. As this horizon of granules is a contribution of excreta (either oral or anal, or both) from animals living in the mineral soil as well as from animals feeding in the F-layer or even in the overhanging vegetation, it is not a typical H-layer. It may be conceived of as a no-man's-land or an overlayer. In places, earthworms castings occur in all degrees of disintegration, but when they have lost their characteristic shape they resemble soil granules. With time these organic granules become compacted and amalgamated to form the upper face of the mineral soil.

Let us now look at our carpets in the fourth dimension, considering the time factor. Time is the weaver each autumn spreading out a new layer of warp. Through the year the fungi weave in the hyphal woof and the minute animals eat away at the carpet, reducing it from say two inches to one. What matters it? Next year a new warp will be laid down and more woof woven in. Thus the carpet is repeatedly renewed from upward downward, under our very feet, so gently, so gradually, that we wot not of it nor of its myriad wildlings.

ON THE RATE OF CHEMICAL REACTIONS

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FROM less than 92 known elements, about a million compounds have been prepared by chemists. More than half of these compounds contain only four elements: carbon, hydrogen, oxygen and nitrogen. How is such a great number of combinations possible?

Certainly there is something strange about this. If we mix two elements, *e.g.*, sodium and chlorine, only three different "compounds" can arise; if we have more sodium than chlorine, practically all the latter will be bound to form rock salt and the remainder of the sodium will be left intact. If we have more chlorine than sodium, chlorine will be left over in addition to the rock salt. There are only three compounds: sodium, rock salt and chlorine. What an enormously different situation we encounter if we consider now the compounds containing only carbon and hydrogen! About ten thousand distinct compounds of these elements are known. The actual number of such compounds is probably only limited by the C and H atoms available to be built into the compounds. Certainly at any particular temperature not all these compounds are stable. At ordinary temperatures, methane is the only hydrocarbon which is stable, in addition to which we can have excess of carbon (graphite or diamond) or hydrogen. No two pure solids of the same composition can be stable over a range of temperature.

Why is it, then, that although a benzene molecule could break up into three acetylene molecules, pure benzene remains unchanged for an indefinite length of time? However, if one adds some suitable compound (a catalyst) the system proceeds very rapidly to equilibrium, the benzene decomposing into acetylene.

It obviously is the slowness of most reactions which allows this almost endless variety of organic substances to exist. This indeed is what makes life possible and prevents our immediate and complete combustion in the oxygen of the air. No wonder that the beginnings of the study of reaction rates are lost in antiquity.

The first measurement of a reaction rate has been made by Wilhelmy in 1850 and the problem of the mechanisms by which chemical reactions proceed has been a center of interest in chemistry ever since. Van't Hoff, in his famous "Étude de dynamique chimique," recognized clearly the *dynamical* nature of chemical equilibria. That is to say, whenever a reaction like

$$2C_2H_6 = CH_4 + C_3H_8$$

comes to equilibrium, this means that the number of ethane molecules being formed in unit time is just balanced by the number of such molecules combining to give methane and propane. The well-known rapid increase of reaction rates with temperature results from the fact that only abnormally violent collisions can lead to reaction and the number of such collisions increases rapidly with temperature. The necessity of high energy concentrations for reactions was pointed out by Arrhenius toward the end of the last century.

At the present time, we believe that the fundamental features of the mechanism of reactions are well understood. This has been possible because of the pioneering work of many brilliant men, only a few of whom we can mention here. W. C. McLewis was the first to calculate the number of violent collisions. To the pioneering work of Marcelin, Polanyi, Bronsted and Herzfeld we owe the gradual development of the notion of the activated state. Rice, Ramsperger and Kassel completed the theory of unimolecular reactions along the lines suggested by Lindemann and Hinshelwood. Lewis and Smith, Daniels and Trautz applied kinetic theory to monomolecular processes and did much in the way of studying systematically many reactions. Later a considerable portion of reactions were found to go faster on the walls, and the understanding of these catalytic processes have been conspicuously advanced by the work of I. Langmuir and that of H. S. Taylor.

The rest of the development is an interesting example of the progress and obstacles and the way they are overcome in the advancement of science. As a matter of fact, we shall see that the calculation of absolute reaction rates is a simple example of the application of statistical mechanics. It is based on the concept that the atoms are moving under the influence of ordinary forces which are also responsible for the chemical valence. The difficulty of physicists in grasping this situation was that they believed on the basis of the older quantum theory that chemical reactions involved rather mysterious quantum jumps. Tolman and Herzfeld derived formulas very similar in principle to those which we shall discuss, on the basis of this theory. Chemists were not bothered by the notion of quantum jumps but were less familiar with the methods of statistical mechanics. As a matter of fact, Rodebush and Rice and Gershinowitz derived formulas which are similar to the ones to be discussed. They, like earlier workers, however, did not make the fullest use of our present knowledge of the nature of forces acting during a chemical reaction.

When the notion of ordinary forces acting between atoms was reestablished by the work of London, it soon became clear how the considerations just mentioned can be formulated on a general basis. This is all that has been done by Polanyi and Pelzer in collaboration with the present writers.

A nice way of representing the motion of the atoms is by a diagram in the "configuration space." Suppose we have three atoms moving with respect to each other in a straight line. The configuration space is two-dimensional then, the X coordinate being the distance of atoms 1 and 2, the Y coordinate the distance between 2 and 3. Every point in this configuration space corresponds to a configuration of the three atoms. The forces between the atoms can be derived from the potential energy for this configuration. If we make a landscape over the configuration space such that the height at any point is equal to the potential energy for this configuration, a ball rolling on this landscape will represent the motion of the three atoms under the influence of the forces between them. The relative position of the atoms will change in reality in such a way that the corresponding point in configuration space always coincides with the position of the ball. If we are interested in a system of more than three atoms or if their motion is not restricted to a line, we must use a configuration space of more dimensions.

Stable chemical compounds correspond to low regions in our landscape. If the ball is in such a low region and has little velocity, it will stay in this region forever. There may be several regions of comparatively low energy, corresponding to several apparently stable groups of molecules. *A reaction will then consist*

in the passing over of our ball from one low region to another.

For such a passage, it needs, first of all, enough energy. The average amount of energy which such systems have is proportional to the temperature. However, at any particular temperature, some systems will have less than the average energy and a very small number, very much more energy. Only the systems with exceptionally high energy will be able to pass from one low region to the other, and the fraction of the systems which have this unusual amount of energy increases very rapidly with the temperature. This fact accounts for the rough empirical rule that the reaction rate doubles with a 10° increase in temperature.

In order to make an actual calculation of the reaction rate of the reaction $H_2 + J_2 = 2HJ$, say, the fundamental idea of Gibbs may be utilized. Imagine a reaction vessel with a great number of H_2 and J_2 molecules. Let us subdivide the vessel into small compartments, each containing one single H_2 and J_2 molecule. The number of collisions between H_2 and J_2 molecules will be still the same as in the original vessel. However, every H_2 can react with one J_2 only so that we need to consider the configuration space of one pair of molecules only, instead of considering the coordinates of all the molecules simultaneously.

The instantaneous state in each compartment can be represented by a point in the configuration space. There will be one point in the configuration space for each compartment. As the molecules move in each compartment, the corresponding points in the configuration space will swarm like people in a mountainous region. To begin with, only one valley in configuration space is populated. The people scurry around apparently aimlessly. Most of them have too little energy to rise much above the floor of the valley. Even those who have enough energy to emerge from the crowd will go uphill at any arbitrary place and only a few of the lucky ones will strike the path that leads into the neighboring valley. The number of these successful ones is all that concerns us. Their number gives us the number of reactions in our original vessel.

We can count these lucky people by multiplying their density at the top of the pass with the velocity with which they are traveling. Account must be taken, of course, of the fact that some of them which passed the crest of the hill, having encountered some obstacle, return without having descended into the new valley.

Both the density of the people in the pass and their velocity are given by standard formulas of statistical mechanics. Indeed, the velocity depends only on the temperature and the mass of the atoms involved. The density depends only on the temperature, the density of population in the valley and the height of the pass above the valley floor. Thus the whole reaction rate depends only on the nature of the landscape in the immediate neighborhood of the pass, the nature of the valley floor and the temperature. It has practically nothing to do, however, with the intervening country. The paths leading from one valley to the other may traverse many lower passes and intermediate valleys. All this will have little effect on the density of the highest pass and thus practically no effect on the reaction rate.

The intermediate valleys correspond to the intermediate compounds, frequently isolated by skillful chemists. These give us important information on the topography of the landscape. The mere fact that they can be isolated shows, however, that they inhabit low valleys and not the critical pass where density determines the rate of reaction.

Of all the quantities entering into the calculation of reaction rates the height of the pass above the valley is responsible for the greatest uncertainty. Except for a few cases, so far, it has always been necessary to derive this value from the

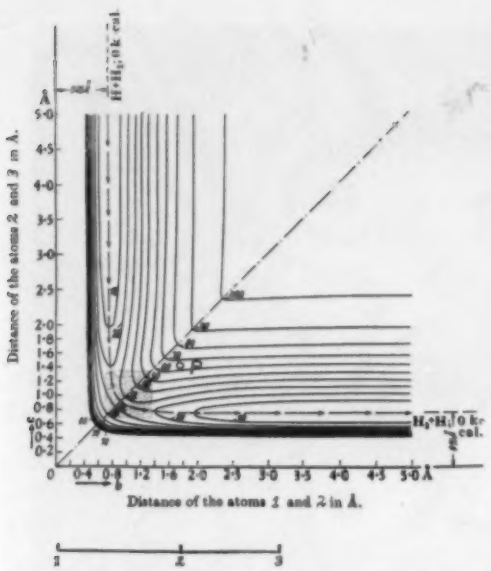


FIG. 1. THE CIRCLE P IN THE FIGURE ABOVE CORRESPONDS TO THE LINEAR CONFIGURATION OF THE THREE ATOMS AS INDICATED BELOW. THE FIGURE ABOVE REPRESENTS THE ENERGY SURFACE FOR ALL LINEAR CONFIGURATIONS. THE HEIGHT OF THE SURFACE ABOVE THE PLANE OF THE FIGURE IS CHARACTERIZED BY THE CONTOUR LINES, AS IS USUAL ON MAPS.

experiments on reaction rates themselves. An improvement of our knowledge of the

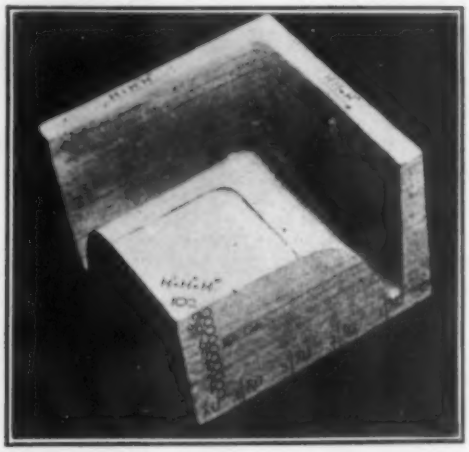
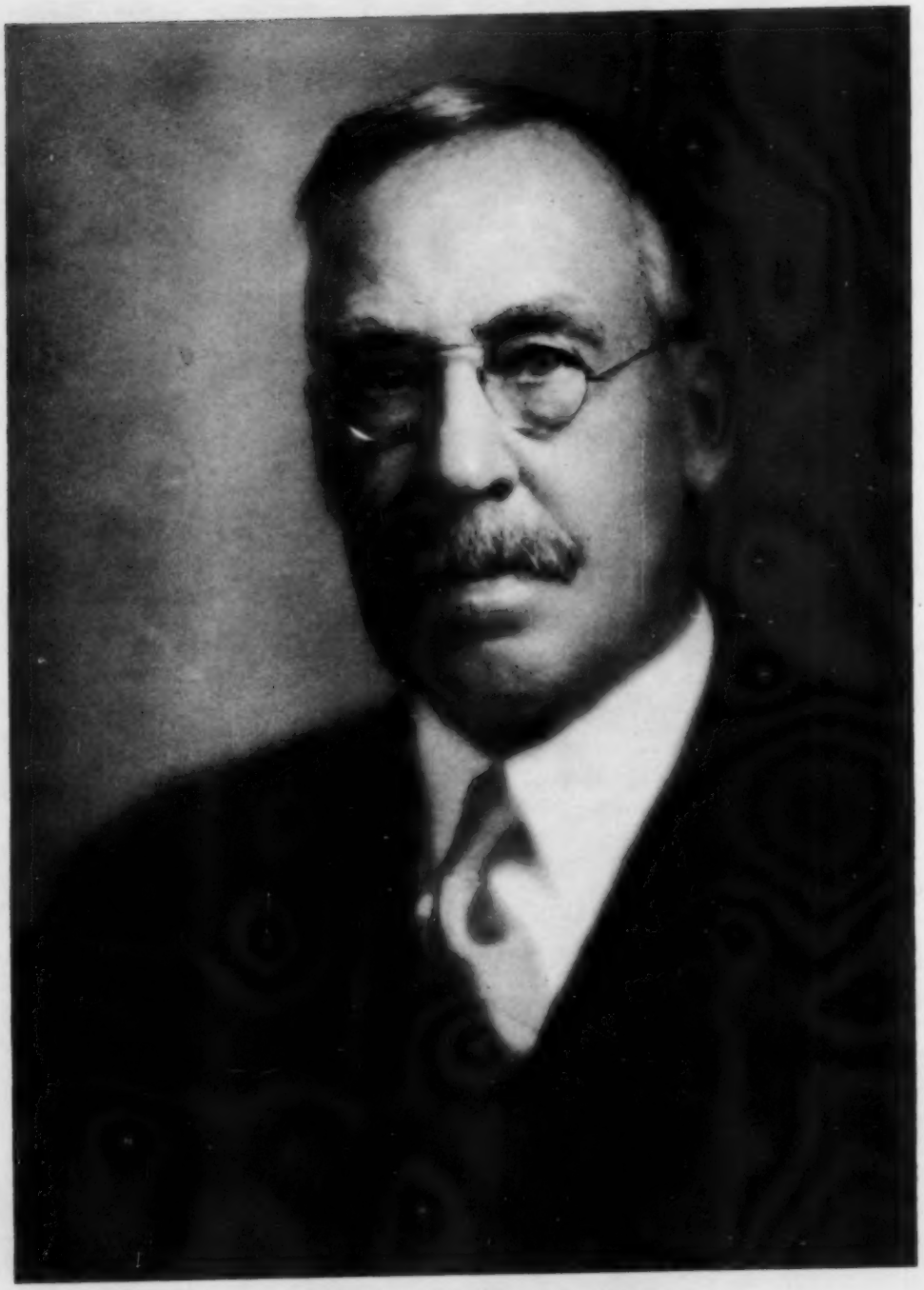


FIG. 2. PHOTOGRAPHIC PICTURE OF THE LANDSCAPE OF FIG. 1, TAKEN FROM THE WORK OF C. F. GOODEVE.

landscape is highly desirable, therefore. This will be achieved, no doubt, in two different ways—partly by a further improvement in the theoretical calculation of such surfaces, partly also by experimental investigations from which empirical rules can be derived. The question of absolute rates thus reduces to the construction of the appropriate energy surfaces, after which it becomes a simple problem of arithmetic.



WILLIAM MORTON WHEELER

THE PROGRESS OF SCIENCE

WILLIAM MORTON WHEELER

THE sudden death of Wheeler, on April 19, seems in a manner incredible. For so many years he has been part of our entomological world, and we had not contemplated a time when we should have to do without him. In a true sense, we need not think of such a time, for his works remain and will retain their essential vitality far into the future. Posterity will read them with profit and admiration, but we are sorry for those who did not know the living, energetic, enthusiastic Wheeler as we have known him in the flesh. I think of the summer of 1906, when Wheeler came out to Colorado to take part in an expedition to Florissant. We were hunting fossil insects, and digging a trench in the volcanic shales, uncovered many remarkable species, which have since been described. But Wheeler also looked for living ants, and we sprawled on the ground, while he showed us the red *Polyergus* and described to us its slave-making operations. He had an almost uncanny knowledge of the ants, and could recognize most of the North American kinds at a glance. Thus we spent the days hunting and observing, and in the evenings discussed many matters far into the night. In Chicago, in Texas, at the American Museum in New York, and in later days at Harvard, Wheeler has made his great contributions, not only to the literature of his subject, but also to the enrichment of the lives of numerous disciples, many of whom are now doing important work. It has been impossible to escape his influence, for, as was once said of another man, when he did not reach the people, he reached the people who reached the people.

Wheeler's best *apologia*, so far as it concerns his work on ants, is found in the preface to his classical work "Ants," published in 1910. He says: "My work began in an endeavor to increase our systematic knowledge of the North American ants, but I was fascinated by the activities of these insects and soon saw the advantage of studying their taxonomy and ethology conjointly. This method, which was, indeed, unavoidable, has greatly retarded the appearance of the present work, for it was impossible to write about the behavior of many of our most interesting forms till their taxonomic status had been definitely settled. On the other hand, I could find no satisfaction in devoting all my energies to collecting and labelling specimens without stopping to observe the many surprising ethological facts that were at the same time thrusting themselves upon my attention. My observations have now covered so much of our fauna that I shall soon be able to publish a systematic monograph, which will, I hope, enable the student to form a rapid acquaintance with our ants."

Alas! the monograph has not appeared, at least not in its entirety, though Wheeler has published revisions of several of the more important genera.

Trying to define Wheeler's type of mind, it may perhaps be said that it was restless and expansive. There are college professors who are content to reach a certain state of perfection, and let it go at that, teaching the same things, in the same way, year after year. But Wheeler always appeared to be going somewhere, and thus when he took up the study of American ants, he soon found himself involved with the ants of the world on the one hand, and the whole field of comparative psychology on the other. This led him to visit Australia to see the remarkable and primitive ant-fauna of that country, and to write at great length on

the ants of Africa, of Central and South America and of many parts of Asia. Every one of his papers, no matter how technical or taxonomic, was illuminated by comments on evolution, geographical distribution and similar broad topics.

There existed a parallel yet different type of man in Switzerland. This was Forel, the great European myrmecologist, who also concerned himself with psychology, and was in fact an authority of note on diseases of the mind. Forel and Wheeler were in active cooperation for many years. Wheeler once described to me some of the incidents of his visit to Forel, and told with relish the parting comment of the Swiss, "Wheeler, you are outwardly calm, but inwardly perturbed. I am outwardly perturbed, but inwardly calm." Wheeler declared that this was essentially true; as we think of it now, he combined in one individual a high development of the emotional and intellectual faculties. One can imagine that he might have been a great religious or political leader, had he not adopted the principles and practices of the scientific worker.

Wheeler not only had an admirable English style, but was quite at home with German and French. It was thus possible for him in 1925 to act as exchange professor at the University of Paris, and while there he saw the unpublished manuscript of Réaumur. This eighteenth century worker was a pioneer of a type to instantly win Wheeler's admiration, and the result was the publication, in English, of a translation of Réaumur's treatise on ants. This includes numerous critical annotations, and an account of the life and work of Réaumur.

The main facts concerning Wheeler's life will be told elsewhere. Born at Milwaukee in 1865, he early came under German influences, attending a German-American college. He took up the study of entomology very early, being first attracted to it by observing some burying-beetles working under a dead animal. After a time, he became the happy possessor of Say's "Entomology," which contained descriptions of many North American insects. He once told me that, when very young, he found numerous beetles which were not in Say, and innocently proceeded to describe them, supposing them to be new. This effort was of course never published, but it is of interest as showing at an early age the habit of going beyond the books, reaching out to nature for new revelations of her works.

Some of his early work, which would indeed have given him a permanent place in zoology, if he had done nothing else, was in the field of embryology. That he gave up such laboratory studies and turned to the observation of living things showed the strong and constant trend of his mind. When, in later years, he wrote many severely taxonomic papers, they were always illuminated by the thought of vital processes, which in the light of his great knowledge could be inferred even from cabinet specimens.

We should like to think that Wheeler will have worthy successors. But one of the most eminent American zoologists recently expressed to me his regret that, as it appeared to him, the young men were growing up to be admirable and even marvelous technicians, but with little breadth of view. It is through the development of this technique, and the intensive work of the laboratories, that great advances are now being made in the field of biology. Yet the work of Wheeler, looking toward the processes of nature as seen in the field, and the results of those processes as expressed in classification, calls us to a vast undertaking which seems to have no end, in which all zealous students may have a part. As we proceed, we learn many things, while at the same time meeting innumerable unsolved problems, calling us onward.

No laboratory work, no experimental methods, can take the place of such studies. Taught by Wheeler, we can in new ways go to the ant, and learn of its ways, and be wise.

T. D. A. COCKERELL

THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE National Academy of Sciences held its seventy-fourth annual meeting on April 26, 27 and 28, at the academy building in Washington, D. C. One hundred and thirty-one members were present—nearly one half of the total membership. At this time of year Washington is especially beautiful and attracts many visitors who come to enjoy the city and to take part in meetings and conventions of different groups. During the last week in April approximately one thousand scientists attend the meetings of the National Academy of Sciences, the American Geophysical Union, the American Physical Society, the American Meteorological Society and the Institute of Radio Engineers with the American Section of the International Scientific Radio Union. The stimulus given by these and other gatherings and by personal contacts and conferences is an important aid to progress in science.

The scientific sessions of the recent annual meeting were well attended and the papers aroused interest and discussion. The distribution, among the sciences, of the 43 papers on the program was: mathematics, 3; physics, 7; chemistry, 3; crystallography, 1; paleontology, 1; oceanography, 2; genetics, 6; pathology, 1; physiology, 4; embryology, 2; biochemistry, 3; psychology, 2; anthropology, 1; biographical memoirs, 6. Members of the academy read 29 papers; non-members, 14 papers.

Brief mention of several of the papers will serve to indicate the variety and

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PROFESSOR OF PHYSICS, UNIVERSITY OF CHICAGO.

DR. O. E. BUCKLEY
DIRECTOR OF RESEARCH, BELL TELEPHONE LABORATORIES.

scope of the subjects presented. Dr. O. E. Schotté, of Amherst College, discussed "Embryonic Induction in Regenerating Tissue," as illustrated by experiments on transplanting embryonic eye-cups of *Rana pipiens* below the skin of regenerating tails of large tadpoles of the same species. These eye-cups induced the neighboring tissues to differentiate into typical lenses and eventually to develop adjacent organs as neoformations, such as ear vesicles with labyrinth and mouth cavities on the tadpole tail. Dr. Schotté concluded that "every cell possesses potentially everything to produce any type of tissue or organ." Dr. Simon Flexner, of the Rockefeller Institute for Medical Research, described in a paper on "Immunity and Reinfection in Experimental Poliomyelitis" the effects of reinoculation of monkeys which had recovered from attacks of poliomyelitis (infantile paralysis) experimentally induced. The monkeys were found to be subject to reinfection by the nasal route, thus indicating that vaccination, in the case of monkeys, does not give the protection that recovery from the natural disease affords. "It is thus apparent that the two immune states in poliomyelitis, one based on recovery from an attack of the disease and the other symptomless reaction to virus injections are not identical. They do agree in that under both sets of conditions antibodies usually appear in the blood."

Investigations by Dr. H. G. Barbour, of Yale University, on the effects of the presence of heavy water (deuterium oxide) in mice on the nervous system were described in a paper on "Sympathomimetic Influence of Deuterium Oxide." Dr. Barbour and associates found that, when half the body water of a mouse is replaced by heavy water, the animal dies; "when, however, the body water is but one fifth saturated with heavy water the mouse survives, but lives at a faster rate; metabolism is increased by some 20 per cent., usually with eleva-

tion of body temperature. The results obtained indicate that the effects may be due to excessive stimulation of sympathetic nerve mechanisms (sympathomimetic action)."

Drs. E. N. Harvey, G. A. Hobart, III, and A. L. Loomis, of Princeton University and the Loomis Laboratory, reported upon "Cerebral Processes during Sleep as Studied by Human Brain Potentials." They discovered that the electrical potentials of the brain differ greatly in pattern from person to person; at one extreme, the wave frequency is 10 per second; at the other, from 30 to 40 per second. In an individual of the 10-beat type profound changes in rhythm occur during a period of sleep; as he falls asleep the 10-second rhythm is interrupted and is replaced by large random potentials; deep sleep is characterized by random potentials plus short bursts of 14 per second rhythm. These phenomena enable the observer to distinguish the states of sleep in persons of this type.

Dr. F. G. Benedict, of the Carnegie Institution of Washington, described experiments made on geese and mice to ascertain if body fat is a factor in heat production. He found that the daily heat production and the heat production per gram of dry protein of a fat mouse weighing 60 grams was more than twice that of a 20-gram albino mouse. Similar tests on geese indicate that body fat plays a part in metabolism. "The obese must pay in calories for their fat loads."

Drs. H. W. Haggard and L. A. Greenberg, of Yale University, discussed "The effects of alcohol as influenced by blood sugar." They found that the intoxicating and lethal effects of grain alcohol are due to its action on the brain and that the concentration of alcohol in the brain depends upon that in the blood. The increase of sugar in the blood after a meal greatly lessens the pharmacological effect of alcohol. In rats, which are fed sugar, the toxicity of alcohol is influenced in-

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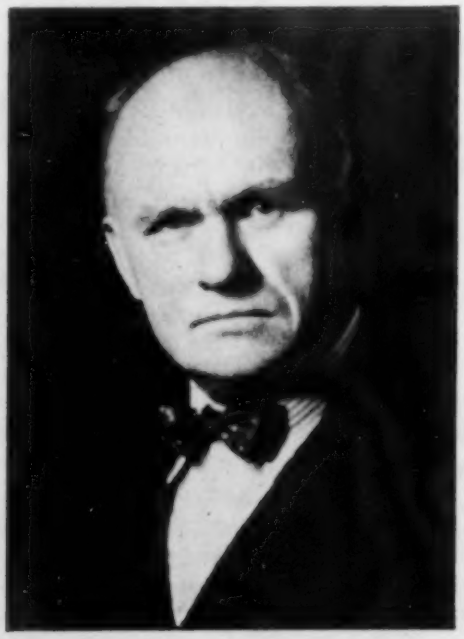
versely by the amount of sugar in the blood. This modifying effect of sugar upon the action of alcohol is connected with the combustion of alcohol in the tissues. Methyl alcohol and ether are not appreciably burned in the body, and the concentration of sugar in the blood does not influence their lethal concentrations. Evidence has been obtained indicating that man reacts similarly.

Drs. G. L. Streeter, E. A. Park and Deborah Jackson, of the Carnegie Institution of Washington, in a study of the "Hereditary Vulnerability of Dietary Effects in the Development of Bone," found that when young rats at the end of the first month are placed for three weeks on a rachitic diet and then returned to a normal diet the effect of this treatment persists throughout the life of the rat and is transmitted to its young. Following 14 generations of such selection and inbreeding this strain of rats reacts more severely to a rachitic diet than do non-treated rats. "From such experiments we can understand why under equally unfavorable conditions the children in some families acquire rickets, while others do not."

Drs. L. H. Germer and K. H. Storks, of the Bell Telephone Laboratories, investigated the "Structure of Langmuir-Blodgett Films of Stearic Acid" by preparing multiple molecular layers of stearic acid upon metal blocks by the Blodgett method. They found that electrons scattered from such built-up surface films produce diffraction patterns consisting of segments of sharp lines normal to the specimen and arranged along diffuse inclined bands which are parallel and equally spaced. The stearic acid is formed into large monoclinic crystals and arranged with a long crystallographic axis parallel to the long axis of the individual molecules and inclined 57° to the surface plane, and with two orthogonal axes of lengths 9.4A and 5.0A in the sur-

DR. CALVIN B. BRIDGES
DEPARTMENT OF GENETICS, CARNEGIE INSTITUTION OF WASHINGTON, PASADENA.



DR. CARL G. HARTMAN
DEPARTMENT OF EMBRYOLOGY, CARNEGIE INSTITUTION OF WASHINGTON, BALTIMORE.

DR. FRANCIS B. SUMNER
PROFESSOR OF BIOLOGY, SCRIPPS INSTITUTION OF OCEANOGRAPHY, UNIVERSITY OF CALIFORNIA.

DR. CHARLES THOM
SOIL MICRO-BIOLOGY, U. S. DEPARTMENT OF AGRICULTURE.

face plane, in agreement with that of single crystals of stearic acid.

Dr. G. H. Parker, of Harvard University, in a study of neohumors, which are hormones produced by the secretory portions of the nervous system or by glands immediately associated with this system, found that neohumors from obvious glands are soluble in water and are carried by the blood (hydrohumors); those from nerve terminals are insoluble in water but soluble in ether or oil (lipohumors), and are local in action, while hydrohumors are general in action. It is thus evident that "neohumors, contrary to the older view, are an extremely diverse and numerous set of substance."

Dr. Warren H. Lewis, of the Carnegie Institution of Washington, reported upon the part played by macrophages which come from the large mononuclear white blood cells and are scattered in the tissue spaces throughout the body. They serve not only as scavengers, but as "pinocytes" (drinking cells) and probably maintain the body fluids in proper condition by "digesting and thus modifying the tissue fluids which bathe most of the cells of the body."

From studies on the "Plankton and Radiolarian Ooze in Paleozoic Formations of New York," Dr. R. Ruedemann, of the New York State Museum, concluded that "radiolarian chert represents radiolarian ooze formed at a depth corresponding to that at which the ooze is formed to-day and that the bottom of the Appalachian geosyncline sank at times to abyssal depths."

Drs. M. A. Tuve, L. R. Hafstad and N. P. Heydenburg, of the Carnegie Institution of Washington, in a statement on "The structural forces of atomic nuclei" showed from measurements on the angular scattering of a beam of protons passing through hydrogen gas that the Coulomb law of repulsion fails at very close distances. Their measurements in-

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dicate that the proton-proton forces are nearly identical with the proton-neutron and the neutron-neutron forces; these three attractive forces are the structural basis for the formation of the nuclei of the chemical elements. Observations in the region of 200 to 500 kilovolts prove that "the forces between two protons change from repulsion to attraction as they are brought close together."

Drs. P. A. Levene and Alexandre Rothen, of the Rockefeller Institute for Medical Research, discussed the "Mechanism of the Reaction of Substitution and Walden Inversion" and proved by experiments with secondary normal aliphatic alcohols and corresponding amines and the three corresponding chlorides, bromides, and iodides that, with certain substitutions on the optically active carbon atom, "one substitution by a negative ion takes place on the positive, the other on the negative end of a dipole."

The Monday evening public lecture was given by Dr. G. H. Whipple, of the School of Medicine and Dentistry, University of Rochester, New York, on the subject "The Romance of Hemoglobin." Dr. Whipple has studied the production of new red cells in the blood of dogs made anemic by bleeding under controlled experimental conditions and has measured the production of hemoglobin as influenced by various factors. He has found that when red cells wear out in the circulation they disintegrate and the hemoglobin or red coloring matter of the blood breaks down into three fractions: iron, a pigment radicle (hemin), and the large globin fraction or protein part. The liver and bone marrow are the chief agencies for the production of new red cells and hemoglobin. Diet is an important factor by which we may control hemoglobin production. Liver gives a maximal production of hemoglobin; green vegetables are in a mid position; fruits may be active (apricots, prunes, peaches) or may be inert (berries). Dr. Whipple's interest-

ing lecture on this important but difficult subject was enthusiastically received by the many listeners.

On Monday afternoon the academy members and guests visited the Folger Shakespeare Library on invitation of its director, Dr. Joseph Quincy Adams, who showed the group over the library, explained its purposes and exhibited many of the rare books and treasures from the Elizabethan period in the Folger collection. The visit was extremely interesting and was greatly appreciated by the academy members.

At the annual dinner President Lillie delivered, at the request of the committee on arrangements, a brief address on the status of the academy and on its accomplishments during the past year. He mentioned briefly the special problems on which the government has sought the advice of the academy since the last annual meeting. These requests are referred to the Government Relations and Science Advisory Committee for consideration as they are received. Each problem is studied and reported upon by a special subcommittee appointed for the purpose; its report is transmitted by the president of the academy direct to the government department or agency which sought the advice. This procedure has functioned satisfactorily and with good results in the variety of problems thus far investigated.

Following the president's address, four medals were presented: (1) The Agassiz Medal for Oceanography, awarded to Dr. Martin Knudsen, of the University of Copenhagen; (2) the Henry Draper Medal, awarded to Dr. C. E. Kenneth Mees, of the Eastman Kodak Company; (3) the James Craig Watson Medal, awarded to Dr. Ernest William Brown, Yale University Observatory; (4) the Mary Clark Thompson Medal, awarded to Dr. Amadeus William Grabau, of the National University of Peking, China.

At the business session the membership limit was raised from 300 to 350. Dr. Arthur L. Day, of the Carnegie Institu-

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EMERITUS PROFESSOR OF PATHOLOGY, WASHINGTON UNIVERSITY.

DR. EDWARD C. TOLMAN

PROFESSOR OF PSYCHOLOGY, UNIVERSITY OF CALIFORNIA.

tion of Washington, was reelected vice-president for a period of four years. Dr. H. S. Jennings, of the Johns Hopkins University, was reelected a member of the council, and Dr. O. Veblen, of the Institute for Advanced Study, Princeton, was elected a member of the council, each for a period of three years. Dr. August Krogh, professor of zoophysiology at the University of Copenhagen, Denmark, was elected a foreign associate of the academy. Fifteen men, whose portraits are here reproduced with the exception of Dr. Seth B. Nicholson of the Mount Wilson Observatory, were elected to membership in the academy.

The present membership of the academy is 299; there are 40 foreign associates, with a limit of 50.

The autumn meeting of the academy will be held this year on October 25, 26 and 27 at the University of Rochester.

F. E. WRIGHT,
Home Secretary

THE DENVER MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

IN June this year, scientists from the East and from the West, from the North and from the South, will gather in Denver, Colorado, to attend and take part in the one hundredth meeting of the American Association for the Advancement of Science. The formal sessions will begin on Monday, June 21, and continue during the remainder of the week.

Not only will the Denver meeting be the hundredth one of the association, but it will be the first in which both the Pacific Division and the Southwestern Division have joined with the parent organization. These divisions of the association will be responsible for some of the most important features of its programs. Of the principal evening addresses, one will be delivered by Dr. Herbert M. Evans, president of the Pacific Division, and the other will be delivered by Dr. A. E. Douglass, representing the Southwestern Division. Since the association is American in the continental sense, distinguished Canadian scientists will participate, as usual, in its meeting this summer. Indeed, the meeting will be in a wider sense international, for Dr. Nevil V. Sidgwick, a distinguished representative of the British Association for the Advancement of Science, will deliver the Maiben Lecture.

The 18,000 active members of the association are organized into 15 special sections which, together with 161 affiliated and associated societies, cover practically all pure and applied science. Consequently, the subjects on the programs of the meeting will range from the mysterious cosmic rays to the "dust bowl" problem, from solar storms and the aurora borealis to loathsome leprosy. And there will be papers by specialists on prehistoric Indians, at one extreme, and on current scientific developments in methods of education, at the other. Engineers will discuss and visit great works in concrete and steel, while mathematicians and economists will produce equally interesting and valuable structures in the realms of statistics. Geologists will look down into the earth, and astronomers will turn their eyes upward toward the stars. Even though religion finds no formal place on the programs of the meeting, under the deep blue Colorado skies and in the presence of its white-crowned mountains, many a visitor will feel with Byron—

> Not vainly did the early Persian make
> His altar the high places, and the peak
> Of earth-o'ergazing mountains, and thus take
> A fit and unwalled temple, there to seek
> The Spirit, in whose honour shrines are weak,
> Upreared of human hands. Come, and compare
> Columns and idol-dwellings, Goth or Greek,
> With Nature's realms of worship, earth and air,
> Nor fix on fond abodes to circumscribe thy prayer.

It is fitting that the centenary meeting of the association should be held at Denver, for this fine city is on the roof of the continent and almost at its center. It is the terminus of six principal railroads, which offer 30-day summer excursion rates at less than one and three quarters cents per mile; and leading into the city from every direction are perfect concrete roads. At the very feet of some of the most majestic mountains in North America, it rests on a fertile plain made refreshingly and delightfully green by irrigation. Denver is a city of homes and broad tree-lined streets and beautiful parks. It is a center of education and culture. Its early carefree spirit, born on the range and in the mine, has been succeeded by the culture and refinement of schools and churches and libraries without its losing the cordial hospitality characteristic of the frontier.

Denver is the center from which one may take a remarkable number and variety of mountain excursions. Four times daily transportation companies take visitors over the circle of Denver Mountain Parks, including visits to historic Golden, once the capital of Colorado, and passing over Lariat Trail by Sensation Point, Windy Saddle and Hairpin Curve to the top of Lookout Mountain, on which is located the tomb of "Buffalo Bill," the most romantic character of the days of thundering buffaloes and Indians on the warpath. Even more sensational is the 138-mile Mt. Evans-Echo Lake excursion, made daily, as well as several other comparable trips. And, finally, there is the incomparable Rocky Mountain National Park 250-mile Circle Tour, during which the visitor drives several miles along the continental divide at an elevation of more than two miles. At other times he winds his way through long canyons cut deep by ice and water and in the cool shade of which columbines grow. He spends a night at Grand Lake at an altitude of 8,370 feet, and on the next day passes through Arapaho National Forest, by the western portal of six-mile-long Moffat Tunnel, over Berthoud Pass, at an altitude of 11,300 feet, and back to Denver through Clear Creek Canyon.

Visitors to the meeting of the association in Denver this June will have not only feasts for the mind at its scientific sessions, but feasts for the soul in its inspiring excursions.

F. R. Moulton,
Permanent Secretary

THE MEMPHIS MEETINGS ON EXPERIMENTAL BIOLOGY

Going to a Southern city for the first time in its history, the Federation of American Societies for Experimental Biology held its annual meetings in Memphis, Tennessee, from April 22 to 24. The American Institute of Nutrition gave its usual program of papers in advance of the main sessions, on April 21. The registration was the third largest in the history of the federation, totaling 1,106. The meetings were held in the Hotel Peabody, whose commodious mezzanine floor was able to accommodate all ten of the sectional meetings which progressed simultaneously, permitting a more easy movement from one program to another than has been possible in other recent conventions of the federation.

The sessions were crowded with reports of new advances in the fields of physiology, biochemistry, pharmacology and pathology. Nearly 500 papers were presented. High lights of the meetings included the discussion of the electroencephalogram by Dr. Hallowell Davis, of Harvard Medical School, the review of the nutritive significance of the amino-acids by Dr. W. C. Rose, of the University of Illinois, and the address of Dr. Thorvald Madsen, chairman of the health

committee of the League of Nations, who described the work of his committee in setting up international biological standards.

Papers presented before the sectional meetings covered a vast territory, from the description of a new factor in the Vitamin-B complex responsible for black hair color, made by Dr. Agnes Fay Morgan, of the University of California, through reports of an electrical wave generated at the time of ovulation, reported by Drs. Reboul, Friedgood and Davis, of Harvard University, to the first demonstration of secretory nerves to the liver, described by Drs. Tanturi and Ivy, of the Northwestern University Medical School. The sectional meetings were more than usually well attended and were characterized by vigorous discussions. A thousand people crowded the convention hall of the Peabody on Thursday morning, April 22, to listen to papers presented before the joint sessions of the four federated societies, over which Dr. Alphonse Dochez, federation chairman, presided.

The usual program of demonstrations was given on the afternoon of the 23rd, in the laboratories of the College of Medicine, University of Tennessee, which acted as host for the meetings. Local arrangements were made by a committee headed by Dr. O. W. Hyman, chairman, and Dr. T. P. Nash, secretary. Tea was served in the new University Center, by the ladies of the faculty.

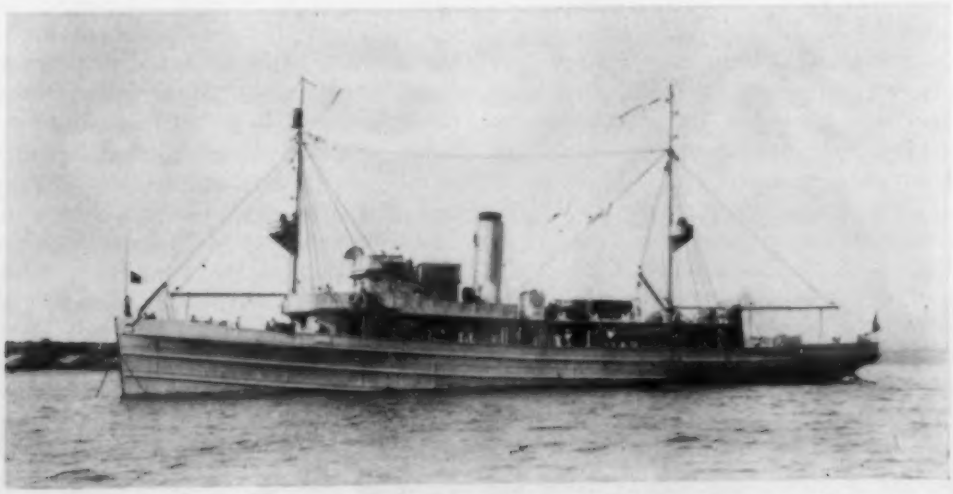
The members of the federation were given opportunities to visit the great cotton warehouses and other industries connected with the cotton business, to inspect the extensive slum clearance projects and to view the levee system which protects the city and surrounding low lands from flood waters.

WILLIAM R. AMBERSON

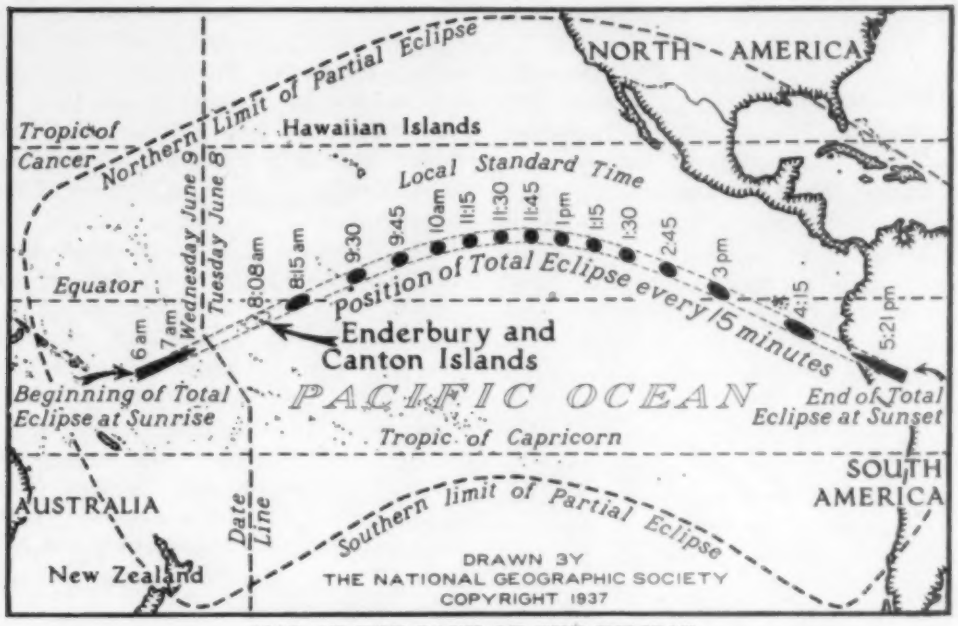
THE ECLIPSE EXPEDITION OF THE NATIONAL GEOGRAPHIC SOCIETY AND THE UNITED STATES NAVY

THE total solar eclipse of June 8, 1937, longest in 1,238 years, will be observed from a "desert island" in the Pacific Ocean by a large expedition under joint auspices of the National Geographic Society and the United States Navy, equipped for many phases of eclipse observation. The expedition sailed from Honolulu on May 6.

Although the path of totality will



THE *U. S. S. AVOCET*, WHICH CONDUCTED THE EXPEDITION TO THE PHOENIX ISLANDS.



MAP OF THE PATH OF THE ECLIPSE.

sweep 8,800 miles across the Pacific from near the New Hebrides to the coast of Peru, there are only two small coral atolls in this entire distance which offer suitable conditions for eclipse observation. These are Canton and Enderbury Islands, part of the Phoenix Group, 1,900 miles southwest of Hawaii and just south of the Equator. Because the islands are so little known, it was necessary for the National Geographic-Navy Expedition to choose which of the islands to occupy after arriving in the vicinity and observing local conditions.

Both islands are not more than 25 feet above sea level, are uninhabited and have central lagoons. Canton is only nine miles long and four miles wide, while Enderbury is about one tenth as large. Considerable guano has been collected from the Phoenix Group in the past, and coconut palms have been planted on some of the islands.

The scientific program of the expedition includes spectrographic observations of the corona and the chromosphere; black and white photographs of the corona with various exposures and light filters; motion pictures of the entire eclipse; timing of the contacts of the sun and moon; measurements of the total light of the corona and of its polarization; and observations of the effect of the eclipse on the ionosphere as indicated by radio signals sent and received inside the band of totality. The eclipse colors will be recorded both by natural color photography and by an artist who will make a painting of the phenomenon.

A unique feature of the expedition will be a series of radio broadcasts from the island telling of the preparations and everyday life of the expedition, and culminating in a description of the eclipse itself.

The scientific leader of the expedition is Dr. S. A. Mitchell, director of the Leander McCormick Observatory, University of Virginia, and veteran of nine previous eclipse expeditions. Captain J. F. Hellweg, U. S. N., Ret., superintendent of the U. S. Naval Observatory, is in charge of the Navy's participation.

Other members of the party are: Dr. Paul A. McNally, S.J., director, Georgetown College Observatory; Dr. Irvine C.

Gardner, National Bureau of Standards; Dr. Floyd K. Richtmyer, dean of the Graduate School, Cornell University; Dr. Theodore Dunham, Jr., Mount Wilson Observatory; Charles G. Thompson, president, Foundation for Astrophysical Research; John E. Willis, U. S. Naval Observatory; Charles Bittinger, artist, Washington, D. C.; Richard H. Stewart, staff representative, National Geographic Society; Walter Brown and M. S. Adams, radio engineers, and George Hicks, radio announcer, all of the National Broadcasting Company. Lieutenant Thomas B. Williamson, U. S. N., is in command of the *U. S. S. Avocet*, which conducted the expedition to the Phoenix Islands; and Dr. Herman A. Gross, U. S. N., has been assigned to look after the health of the party.

Dr. Mitchell and Dr. Richtmyer are members of the National Academy of Sciences and Dr. Mitchell is president of the Commission on Eclipses of the International Astronomical Union.

Dr. Mitchell and Dr. Dunham will record the spectrum of the corona and the flash spectrum, the latter being visible briefly just after totality begins and just before it ends. Dr. McNally will photograph the corona, using the same two cameras he employed successfully during the solar eclipse of 1932, with various light filters. Dr. Gardner will make both black and white and natural color photographs with a 19-foot camera of his own design, with which he obtained excellent results during the eclipse last June in the U. S. S. R. Dr. Gardner has equipped his telescopic camera with a rotating disk with portions cut away in such a fashion that the faint, outer portion of the corona can be given a much longer exposure than the bright portion visible near the rim of the moon.

Dr. Richtmyer will measure the coronal light and its polarization. Mr. Thompson will cooperate with Dr. Dunham in spectrographic observations. The Naval Observatory representatives will devote special attention to timing the contacts of the sun and moon. The records of these times will be extremely useful in the observatory's function as time-keeper for the nation. Mr. Bittinger will paint the eclipse and Mr. Stewart will make motion pictures of the entire event.

The *Avocet* is a former mine sweeper which has been converted to a seaplane tender. The ship will be anchored offshore throughout the stay of the expedition on location. Members of its crew will be detailed to assist the scientific party when it sets up camp on one of the islands. In the three weeks between arrival at the islands and the occurrence of the eclipse, the party planned to lay cement foundations for instruments, to determine the island's exact location and to make other preparations.

The width of the path of totality will vary from 125 miles at either end to 155 miles in the center, and will be about 140 miles in the Phoenix Islands. Duration of totality will be 4 minutes and 9 seconds on Enderbury Island, and three minutes and 35 seconds on Canton. The maximum duration, 7 minutes and 4 seconds, will occur at noon at a point in the open ocean nearly 1,500 miles from the nearest land. The path of totality will cross the International Date Line in the mid-Pacific, so that the eclipse actually will begin on June 9 and end on June 8. Totality will commence on Canton Island at 7 : 39 A.M. local civil time, and on Enderbury at 7 : 42. This corresponds approximately to 2 : 15 P.M. Eastern Standard Time. The altitude of the sun above the horizon at mid-totality will be about 22 degrees on both islands.

The unusual duration of this eclipse, the longest since 699 A.D., is due to a coincidence of three factors: It occurs near July 1, when the sun is at its greatest distance from the earth; it occurs at a time of the month when the moon is closest to the earth; and the moon's shadow in this instance falls near the Equator.

G. G.

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